S. HRG. 101-96

AGING AIRCRAFT

HEARING

BEFORE THE

SUBCOMMITTEE ON AVIATION

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

AGING AIRCRAFT

APRIL 11, 1989

Printed for the use of the
Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

98-741 O WASHINGTON : 1989

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S261-44

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ERNEST F. HOLLINGS, South Carolina, *Chairman*

DANIEL K. INOUYE, Hawaii	JOHN C. DANFORTH, Missouri
WENDELL H. FORD, Kentucky	BOB PACKWOOD, Oregon
J. JAMES EXON, Nebraska	LARRY PRESSLER, South Dakota
ALBERT GORE, JR., Tennessee	TED STEVENS, Alaska
JOHN D. ROCKEFELLER IV, West Virginia	ROBERT W. KASTEN, JR., Wisconsin
LLOYD BENTSEN, Texas	JOHN MCCAIN, Arizona
JOHN F. KERRY, Massachusetts	CONRAD BURNS, Montana
JOHN B. BREAUX, Louisiana	SLADE GORTON, Washington
RICHARD H. BRYAN, Nevada	TRENT LOTT, Mississippi
CHARLES S. ROBB, Virginia	

RALPH B. EVERETT, *Chief Counsel and Staff Director*
WALTER B. MCCORMICK, JR., *Minority Chief Counsel and Staff Director*

SUBCOMMITTEE ON AVIATION

WENDELL H. FORD, Kentucky, *Chairman*

J. JAMES EXON, Nebraska	JOHN MCCAIN, Arizona
DANIEL K. INOUYE, Hawaii	TED STEVENS, Alaska
JOHN F. KERRY, Massachusetts	ROBERT W. KASTEN, JR., Wisconsin
LLOYD BENTSEN, Texas	

CONTENTS

	Page
Opening statement by Senator Ford	1
Opening statement by Senator McCain	2
Opening statement by Senator Exon	3
Opening statement by the Chairman	4

LIST OF WITNESSES

Broderick, Anthony J., Associate Administrator for Regulation and Certification, FAA	5
Prepared statement	8
Questions of Senator Ford and the answers	19
Questions of Senator Kerry and the answers	23
Cosgrove, Benjamin A., vice president and general manager, engineering division, Boeing Commercial Airplanes	67
Prepared statement	70
Questions of Senator Ford and the answers	82
Kizer, Clyde R., vice president, engineering, and maintenance, Air Transport Association of America	35
Prepared statement	38
Questions of Senator Ford and the answers	53
Warren, Dale S., vice president, engineering, Douglas Aircraft Co., McDonnell Douglas Corp	59
Prepared statement	61
Questions of Senator Ford and the answers	66

AGING AIRCRAFT

TUESDAY, APRIL 11, 1989

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON AVIATION,
Washington, DC.

The subcommittee met at 9:00 a.m., in room SR-301, Russell Senate Office Building, Hon. Wendell H. Ford (chairman of the subcommittee) presiding.

Staff members assigned to this hearing, Carol Carmody, professional staff member; Steve Palmer, senior professional staff member; and John Timmons, minority staff counsel.

OPENING STATEMENT BY SENATOR FORD

Senator FORD. Good morning, ladies and gentlemen. This morning we are going to look into the subject of aging aircraft and what the regulators, the manufacturers and the air carriers are doing about it.

The average age of jetliners operated by the U.S. airlines is just under 13 years old, 21 percent higher than the average age in 1979.

The dramatic increase in air travel since deregulation created demand for aircraft. With gas prices remaining low and airline profits precarious, air carriers have continued to use older aircraft rather than replace them with new fuel-efficient models.

I understand that. Maybe as a business decision it even makes sense. But as chairman of this subcommittee, I have to be concerned about the safety of the flying public.

The National Transportation Safety Board shows 36 accidents and incidents since 1983 in which structural fatigue or corrosion was a factor.

If planes are being operated much longer than originally planned, and with repeated cycles of pressurization and depressurization, it seems that a lot more maintenance is needed. Not only more maintenance, but probably a different kind of maintenance.

We all remember the terrible Aloha accident last year where the top of a 19-year old 737 ripped off. The FAA moved quickly and issued an air-worthiness directive for more inspections of other same-model airplanes.

Other instances like the cargo door that ripped off a 747 in February produced more notices and inspections, but always after the fact.

Has the FAA done enough to mandate safety? Are the mechanics and maintenance personnel able to detect and repair corrosion and fatigue damage?

I have talked to the Navy and the Air Force to find out how those services deal with older aircraft. I was impressed with the programs they have for projecting damage and correcting it without a disastrous event to point it out.

The Navy has the "safe life" concept, which means that aircraft structures and parts are not operated beyond a limit established by extensive testing. Planes are not repaired beyond a certain point; they are just retired.

I know the industry just recently announced that they recommend the required replacement of parts rather than continued repair. This seems to make sense to me, but really, is it enough?

Sometimes an inspection is conducted and the problem is not found, or repair is required and not done properly. I wonder if FAA inspectors and airline mechanics are trained on the problems of aging aircraft. Do they know what to look for and how to fix it?

Checking scores of aircraft for hundreds of rivets has got to be a numbing experience, and worse, it could become routine.

FAA and the industry have got to think about what inspection techniques should be used and how to improve the skill and attentiveness of the people responsible.

We have the FAA here today as well witnesses from manufacturers and the air carriers. I hope they will be able to answer these questions and other questions to reassure the American flying public about the safety of the planes they are flying. If not, I intend to find a way to provide this assurance.

Senator McCain, our ranking member, is here. Senator, do you have a comment before we start the witnesses?

OPENING STATEMENT BY SENATOR McCAIN

Senator McCAIN. Thank you, Mr. Chairman. And thank you for calling this hearing. I think it is an important one. It is clear that the American public feels a need to be reassured that the aircraft in which they fly are indeed safe and that this problem with the aging fleet of aircraft in the United States, as well as worldwide, is one which is going to be adequately addressed.

Mr. Chairman, I do not think there is any doubt that because of the demand for aviation services we will continue to use older aircraft. When we look at the projections for the increases in numbers of passengers, even though we see airlines purchasing more and more new aircraft, I think it is clear that we will see continued use of older aircraft.

By the turn of the century, peak traffic of the last Thanksgiving Sunday will be the norm for the airports and airways throughout this Nation.

I think we ought to understand, however, that an airplane is a very complex and complicated piece of equipment. And to come up with simplistic ideas such as an airplane ought to be retired at a certain age, simply shows either a basic misunderstanding of the nature of aviation or a search for a very easy solution to a very complex problem.

As most of us who have been involved in aviation clearly understand, age is not the determining factor as to whether an aircraft needs to be retired or even undergo extensive maintenance. There are many other much more significant factors such as takeoff and landing cycles, exposure to fatigue, corrosion and other factors which cause the simple factor of age of the aircraft to pale in significance.

We need standards to understand and compensate for the unique nature of an airplane, not things like mandatory retirement ages which, frankly, do not correlate to use.

We must be sure that the inspection and maintenance standards we do develop afford the American people the highest degree of safety possible, and we must continually press forward in this area: more R&D, more training for personnel involved, more vigilance, We cannot afford to scrimp or get complacent.

I think it is well also to point out that we have in existence the Maintenance Review Board. I think it is important to recognize that the amount of funds devoted to maintenance of aircraft has gone up, from 2.65 million in 1978, to 6.15 million in 1987.

And I am sure our witnesses will give us more information on inspection criteria. I think it is of interest to note that in the Aloha incident, that aircraft had complied with all FAA inspection standards. That, of course, should give us sufficient reason to review the entire situation.

I think it is also worthy of note, Mr. Chairman, that the number of FAA inspectors have declined. Hopefully our witness, Mr. Broderick, hopefully will provide us with some additional information on that.

In summary, Mr. Chairman, I am sure we are going to hear from our witnesses today, that we are talking about a very complex piece of machinery. We are talking about equipment that does not age just by calendar years. It ages by use, by corrosion, by hard landings, by various other criteria that we have to set.

I think the American people are understandably concerned. But I have confidence that the witnesses today will give us the necessary recommendations, and indeed, tell us about the procedures that have already been put in place, so that we can ensure that the confidence of the flying public is maintained.

I thank you, Mr. Chairman.

Mr. FORD. Thank you, Senator McCain.

Senator Exon.

OPENING STATEMENT BY SENATOR EXON

Senator EXON. Mr. Chairman, thank you very much.

And first, just let me congratulate you for calling this hearing in a very timely manner.

Myself and others have discussed this problem with you. I think it is a very, very timely problem. It is one, I guess, that I have been asked about at home more than any of the other incidents where we have had accidents or crashes of aircraft.

These seem to be a new phenomenon. I would hope that our expert witnesses today could first, tell us if this is a phenomenon that was anticipated, whether or not we need legislation. I would

hope not, but I can assure the public that it will be forthcoming if we find that is necessary.

Passing laws, in and of themselves, does not guarantee safety, as the chairman of the committee and myself, who have worked very long and hard on this Aviation Subcommittee, know.

But the message should go forth to the industry that we expect some answers.

I do not know what those answers are because I basically am not an aircraft expert. But I do know that, in past years, there have been aircraft that have done an excellent job that have been phased out simply because it was felt that because of their longevity of service they were no longer acceptable to meet the safety standards that we require in commercial aviation.

As has been said here this morning, Mr. Chairman, there is no question of whether in the years ahead we are going to have literal explosion of airline passengers. Therefore, safety has to become a major concern. Inspections, safeguards have to be put in place.

And I will be particularly interested, Mr. Chairman, to find out today from our expert witnesses as to whether or not there is any assured testing program that can be used, or better guidelines than we obviously currently have for certification of aircraft that are safe to carry passengers on United States commercial airlines.

Thank you very much, Mr. Chairman. I look forward to the testimony that we are going to receive this morning, and then some followup questions.

Senator FORD. Thank you very much, Senator Exon.

[I have an opening statement from the Chairman, Senator Hollings that I will include in the record.

[The statement follows:]

OPENING STATEMENT BY THE CHAIRMAN

Last month, a nationwide poll confirmed what many of us feared about the condition of our air transportation system. Overwhelmingly, the American people identified aging aircraft and poor aircraft maintenance as the most critical items affecting the safety of our commercial airlines.

It's no wonder that nearly three-quarters of those surveyed focused on aging aircraft and airline maintenance as the issues of greatest concern. The much-publicized incident in April 1988 involving a 19-year-old Aloha Airlines 737 aircraft opened the eyes of not only the traveling public, but this Committee as well. Yet, even as graphic as that event was, others have followed:

In December, a 19-year-old United Boeing 747 aircraft broke open in flight over the Hawaiian Islands, killing nine.

Also last December, a 14-inch hole tore open in the fuselage of a 22-year-old Eastern Boeing 727 over West Virginia, necessitating an emergency landing.

In January, an engine fell off an eight-year-old Piedmont Boeing 727 aircraft as it took off from Chicago's O'Hare Airport.

If these had been isolated events—with little chance of being repeated—there would be no reason to worry. But the fact is that our commercial airline fleet is aging rapidly, with the average aircraft age almost 13 years. More than one-quarter of the aircraft now in operation are more than 20 years old. This compares poorly to the ages of aircraft currently being operated in the other major industrialized nations.

Why has the issue of aging aircraft been allowed to develop? There clearly are many reasons at play. First, the competitive pressures of airline deregulation have encouraged the airlines to drain every penny they can from their inventory of aircraft—in some cases even beyond their operational safe line. That same pressure has also meant that corners are cut on airline maintenance.

Increased debt taken on by most of the carriers during the merger mania of several years ago has made it difficult for them to finance new acquisitions. And, even if

they can secure that financing, there simply are not enough new aircraft being manufactured to resupply our American fleet in a timely fashion.

This hearing is our first attempt to address the issue of aging aircraft. It is important as we are attempting to develop a baseline for reviewing the actions of the airline industry, aircraft manufacturers, and the FAA as they attempt to address concerns about aging aircraft during the coming months.

It is imperative that the Federal government and aviation industry adequately resolve this issue. We must act to restore the margin of safety for the traveling public—its the only way we will regain their lost confidence.

Senator FORD. We will have the witness from the FAA, and then we will have a panel.

The first witness, then, will be Anthony J. Broderick, associate administrator for for Regulation and Certification, FAA.

Good morning, Tony. We are delighted to have you this morning and look forward to your statement, followed by some questions. So, you may highlight and submit it for the record, or you can give your testimony in full, whichever you prefer.

STATEMENT OF ANTHONY J. BRODERICK, ASSOCIATE ADMINISTRATOR FOR REGULATION AND CERTIFICATION, FEDERAL AVIATION ADMINISTRATION

Mr. BRODERICK. Mr. Chairman, I would prefer to enter my prepared statement in the record and briefly summarize it.

Senator FORD. Without objection, the full statement will be included in the record as if given. So you may proceed with your summary.

Mr. BRODERICK. Mr. Chairman, the design of modern airplanes is required to be very tolerant of failures, whether those failures arise from manufacturing defect, accidental in-service damage, below-standard maintenance, or actual error in the design itself.

Our enviable aviation safety record has its roots in the long-standing requirement that structure be redundant and able to withstand years of heavy use on a day-in and day-out basis.

But good design alone cannot guarantee safety. It must be followed for two or more decades by the best possible maintenance.

When most modern aircraft were designed, the structures were required to be fail safe, for the most part. But the science of damage tolerance had not yet been applied to those designs.

While we cannot change the basis of an existing design, we can change the basis for its maintenance.

In the late 1970s and early 1980s, through a series of advisory materials and mandatory regulations issued by FAA, a major step was taken in upgrading aircraft maintenance programs.

Supplemental structural inspection programs developed then are now mandatory for aging aircraft. These programs take an older fail safe design, like that of the DC-9 or the 727, for example, and re-analyze that structure using the best available stress analysis and fracture mechanics tools, which are applied from the beginning, in today's aircraft designs.

Each important structural element of one of those older designs is thus subject to state-of-the-art analysis. The detailed inspection and maintenance criteria for these aircraft have, for the past few years, been based on the new damage tolerance analyses, which form the very basis for the supplemental structural inspection documents.

The Aloha tragedy which took place a little less than a year ago showed, however, that our maintenance program philosophy needed an adjustment.

In the past, we had concentrated on defining what part of the structure would crack and when those cracks were likely to develop. Then, based on these data, repetitive inspections were defined as part of the program required of airlines operating the aircraft.

These maintenance inspections were required to begin early enough to catch the first cracking expected in the fleet; and their frequency is such that two out of a sequence of three inspections could miss a growing crack, and the third inspection would still occur soon enough to detect a failure in that part of the structure without a catastrophic loss of the aircraft.

It was expected that, even if that particular part of the structure were to fail, the overall redundancy designed into today's aircraft would preclude a massive failure of the type which led to the Aloha tragedy.

A year ago, many of us asked ourselves repeatedly what went wrong. We tried to understand which part or parts of this logical, well-proven safety system needed revamping so that such an accident would never happen again.

We have concluded that a number of things needed changing. These are presented in some detail in my prepared statement, but let me highlight a few of the things I find most significant.

First, we need to focus more on identifying and eliminating weak links in the structure, rather than trying to rely on repetitive inspections to catch the cracks before they are permitted to grow to failure.

This is especially true in the case of structure which is subject to multiple-site damage, where small cracks which start beneath fasteners can suddenly link up to produce the type of failure we saw in the Aloha tragedy.

We have been working closely with a joint government-industry task force to carry out the changes required by this change in maintenance program emphasis.

Late this month or early next, we should issue the first required series of changes stemming from this work. Over 160 structural changes will be proposed for Boeing 727, 737 and 747 aircraft.

By the end of summer, task forces on Douglas and other aircraft should similarly report out, and similar changes will be proposed, so that we will be covering literally every aging aircraft in the fleet.

Another finding of our investigation into aging aircraft focuses on the human element in the inspection system. One of the four sessions at last summer's Aging Aircraft Conference focused on human factors in inspections. I think this is the first time that was ever done, and I was pleased at how receptive the industry was to directing more attention to this area.

FAA hosted a meeting devoted exclusively to human factors issues in aircraft maintenance and inspection last October. The published proceedings of that effort identify a number of productive areas for further work, and we will be doing that.

Finally, I would like to note that prompt and productive actions aimed at building a solid FAA-sponsored research and development

program addressing aging aircraft have already taken place. We will have major program initiatives in structural evaluation; surveillance and integrity prediction; maintenance practice enhancement and new technology development; human factors, as I mentioned a few minutes ago; and perhaps most importantly, technology transfer activities.

We are determined to develop and share the best state-of-the-art safety information and data on a continuing basis among all members of the aviation community, including airlines, manufacturers and, of course, our own inspectors.

This effort, of course, had its genesis in this committee's legislative initiative on research last year.

Mr. Chairman, the FAA places issues dealing with aging aircraft at the top of our list of priorities. It is an area in which we have a long-term commitment. The actions you have seen and will see in the coming months are the first of a series of milestones I expect to stretch over a number of years.

Your leadership and that of other members of this committee, in both legislation and oversight activities, have been key motivating factors in the formulation of our approach. We look forward to continued support from you as we advance the state of the art in this particular safety program area.

I would be happy to answer any questions you or other members may have.

[The statement and questions and answers follow:]

STATEMENT OF ANTHONY J. BRODERICK, ASSOCIATE ADMINISTRATOR FOR REGULATION AND CERTIFICATION, FEDERAL AVIATION ADMINISTRATION, BEFORE THE SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, SUBCOMMITTEE ON AVIATION, CONCERNING AGING AIRCRAFT. APRIL 11, 1989.

Mr. Chairman and Members of the Subcommittee:

I welcome the opportunity to appear before the Subcommittee today to describe for you the FAA's programs to address the issue of aging aircraft. I appreciate your interest in this important topic and look forward to your continued support as we proceed on what I believe is a comprehensive and aggressive program to respond to the challenge presented by an aging airline fleet.

A little less than one year ago, the Aloha accident in Hawaii was a catalyst for focusing renewed attention on the issue of aging aircraft. It led the FAA to critically reexamine its approach toward inspection requirements and other facets of our program through which we have worked to ensure that aging aircraft continue to operate at the highest levels of safety.

We concluded that, although we already knew much about inspecting for corrosion and fatigue, we needed to learn more, and we set out to establish an improved framework of industry-government cooperation, began work to develop an accelerated research and development effort to address these issues, and reached some important conclusions about the regulatory way we have dealt with

aircraft as they grow older. Concurrently, the Congress, with the sponsorship of this Subcommittee, enacted legislation highlighting the need for further research and development work in this area.

One of the first steps we took following the Aloha tragedy was to convene a symposium, last June, in which recognized experts from throughout the world participated. A lot of important information was generated through that symposium and the first steps were taken toward solidifying the groundwork for improved efforts in this area. Equally important, it sent a strong signal that we were vitally interested in coming to grips with this safety concern, and helped establish that improved framework of industry-government cooperation which I mentioned a moment ago.

I would like to briefly describe some of the actions we have taken since, where we are now, and where we are headed. First, though, let me take a moment to highlight the general concern we have with aging aircraft. In simple terms, the life cycle of an aircraft, much like a human being's, can be divided into three parts: infancy, the middle years, and old age. During infancy, many "childhood" diseases occur--in an aircraft, we might call them "bugs," which need to be worked out. And a lot of effort is devoted to learning about any problems experienced in actual operation and ironing them out through corresponding corrective action. In the middle years, most people, or aircraft, are

relatively free from disease, although occasional problems occur which have to be addressed. In later life, there is an expectation of increased problems occurring, and a need for more aggressive monitoring of health factors. In the case of aircraft, those increased problems, which need extra monitoring, typically are associated with fatigue or corrosion, and the means of monitoring those factors has generally been through mandated, increased inspection activity, with replacement of parts or components as needed.

I should clarify one point concerning aircraft. An aircraft's age is not necessarily measured chronologically, although chronological age is the primary factor influencing the state of corrosion. Instead of chronological age, we typically are more interested in the number of cycles an aircraft has flown--a cycle being one take-off, pressurization, depressurization, and landing--since these are the activities which stress an aircraft and its components, consequently leading to fatigue.

I should also make clear that the issue of aging aircraft is one with which we and industry have dealt since the 1970's. There are several approaches in place which have been used as the primary means of responding to aging aircraft, one of which, adopted by the FAA in 1978, is an aircraft design concept called "damage tolerance."

A damage tolerant structure is one which has been designed to tolerate damage due to fatigue, corrosion, or accident and still be able to continue to carry expected operational loads until that damage is detected either by the problem becoming evident or during a scheduled inspection. Scheduled inspections of such components are based on the fracture mechanics characteristics of the part, and are designed to detect any crack before it reaches unsafe proportions. Under the damage tolerance approach, we assume that damage is going to occur to a part. That part must then be designed to safely accommodate that damage until it can be corrected. In some cases where the damage tolerance approach is not appropriate--landing gears, for example--a specific life use is placed on the component.

We believe damage tolerance will provide improvements in aircraft design for future aircraft, but it does not apply directly to most aircraft in the current air carrier fleet because they were certificated prior to our adoption of the damage tolerance rule in 1978. Therefore, to address on a more current basis the need to assure that fatigue and corrosion were detected on aircraft in the fleet, the FAA issued guidance information to industry which outlines methods (including fracture mechanics assessment) to assure safety of older airplanes through additional structural inspections. In other words, we used today's damage tolerance

technology to analyze yesterday's designs and develop a state-of-the-art maintenance program for the existing fleet through improved inspection programs.

The number and extent of these additional structural inspections are based on an engineering analysis that assumes the existence of a crack at all critical locations and determines its growth rate and the point at which it would become unsafe. This approach, which we finalized in concert with industry in 1981, is called the "Supplemental Structural Inspection Documents" (SSID) program. Under SSID, manufacturers are asked to identify all structural components whose failure could affect the safety of the aircraft, and to establish a special inspection program for those components. The FAA through regulatory action then requires the airlines to adhere to the schedules called for in these SSID's.

We have also conducted special airworthiness reviews as potential problems have been identified in the aging fleet. On the whole, these programs have worked well and, over time, have led to a variety of safety improvements, some in the form of airworthiness directives (AD's) which impose regulatory requirements on an operator. Nevertheless, we concluded that these measures alone are not enough.

Following last year's Aging Airplane Conference, the FAA announced that it was implementing six procedures to help evaluate and

maintain safety margins of older aircraft. They are:

1. FAA inspectors will exercise more "hands on" involvement at airlines during heavy maintenance checks of hightime aircraft to ensure a better understanding of fatigue and corrosion.

2. FAA aircraft certification engineers will make field visits to airline maintenance shops to gain more knowledge of the human factors involved in maintenance and inspection.

3. FAA's aircraft certification, inspection, and research and development organizations will jointly develop specific programs to promote safety of older aircraft and engines.

4. FAA will develop agency experts in nondestructive testing and inspection technologies and set up improved training programs.

5. FAA will develop a "lessons learned" document on engine maintenance.

6. FAA aircraft certification personnel will promote and work with industry to develop supplemental structural inspection documents for aircraft used in commuter service.

We have made considerable progress since that time, although much remains to be done. In February 1989, we initiated our "Aging Flight Evaluation Program" by conducting a review of one major airline's heavy maintenance ("D" check) on a Boeing 737 with 70,000 hours. "D" checks involve a complete stripdown of the aircraft to bare metal to check for cracks and other problems. This review was the first of many "hands on" inspections which will take place over the next year that will help us evaluate the effectiveness of corrosion control programs, structural inspection techniques, age-related AD's, and human factors engineering. It will be accomplished by FAA regional inspectors and engineers who will visit air carriers during D-checks of a given aircraft type. This year long program --which will become a standard part of our surveillance during which all air carriers are visited--calls for first inspecting 737's, followed by 727's, 707/720's, 747's, DC-9's, and DC-10's. The information gained, we are confident, will provide a basis for further modification to our aircraft maintenance policies.

We are also working on a comprehensive R&D program. The R&D program will include issues such as multi-site cracking, corrosion, nondestructive testing techniques and equipment, engine nondestructive evaluations, and engine repair practice evaluations. FAA's objective is to develop handbooks on both damage tolerance and corrosion within 3 years of the

program start. A handbook on nondestructive testing equipment may be issued within a year. We also expect to produce an engine practices handbook as a result of our R&D efforts.

The Regional Airline Association (RAA) and the General Aviation Manufacturers Association (GAMA) have established a steering group for a task force to examine aging commuter airplane issues. The FAA attended the first meeting that was held February 1, in Washington. The steering group has called for a general operators/manufacturers meeting to be held during April in Kansas City. FAA will participate in that meeting.

We also have other activities ongoing or planned. We have requested Boeing and McDonnell Douglas to provide training to FAA maintenance inspectors concerning supplemental structural inspection documents and corrosion control. Boeing began its first FAA training session in November 1988. Douglas is currently preparing its FAA training program. The purpose of this training is to familiarize FAA inspectors with the manufacturers' detailed maintenance objectives and specific technical means for dealing with corrosion in their aircraft models.

We issued an AD covering the first 291 737's produced by Boeing, including those aircraft which were produced by the "cold bonding" process. This AD, issued last December, requires that the counter-sunk rivets on the top row of lap joints be replaced with

oversized button-head rivets. We also have proposed in an NPRM that all counter-sunk rivets on the top row of lap joints on Boeing 727's be replaced with oversized button-head rivets.

And, within the FAA, we have taken steps to better coordinate all facets of our aging aircraft program by establishing an Aging Airplane Program Management Team of key individuals who are concerned with each part of the aging airplane problem, running the gamut from transport category aircraft, commuter aircraft, maintenance practices, and testing techniques to human factors.

We plan to investigate the methods, equipment, and procedures used in visual and nondestructive inspection of aircraft structure from both a hardware and a human factors standpoint, to develop updated "probability of crack detection" estimates which will provide us adequate assurance that a crack will be detected, reported, and repaired well before it becomes critical. We expect that the human factors investigation will yield results in areas across the board pertaining to the maintenance of airplanes--ranging from the better preparation of airworthiness directives to better coordination of inspection tasks during a heavy maintenance inspection to an assessment of where the most can be accomplished from an inspection and repair standpoint. We expect to develop methods of using current inspection techniques which are less reliant on vigilance and decisionmaking by the inspector, as well as provide the opportunity for emerging inspection techniques to be beneficially applied in the aviation industry.

We have already made some changes in our approach to airworthiness directives. We have in the past issued airworthiness directives which rely upon repeated inspection to detect damage in aircraft structure. Then, when the damage becomes obvious during one of these required inspections, the damaged areas are required to be modified or repaired. These repetitive inspections continue adding to the maintenance workload as an airplane continues in service and more and more airworthiness directives are issued. We have now changed our philosophy in this regard. We now insist that the manufacturer's engineers make every effort within the time constraints afforded by the safety implications of the problem to develop a permanent or terminating modification that will eliminate the problem and result in little or no increase in the inspection requirements for the airplane. In other words, if a design change or repair can stop a potential problem from occurring, this will generally be our initial preference over the establishment of a process of repetitive inspections.

We are now reexamining, in conjunction with industry, existing Supplemental Structural Inspection Documents to determine their adequacy in light of recent catastrophic events and the industry's service experience with them. We anticipate developing a similar supplemental inspection program for corrosion, which would implement for the current aging fleet the basic corrosion requirements we are studying for possible incorporation into future airplane designs.

And, in cooperation with airlines and manufacturers, we are looking at existing AD's which impose inspection requirements to determine whether the inspections should be terminated in favor of design modifications or repairs. Late this month or early next month, we should issue the first required series of changes stemming from this work: over 160 structural changes will be proposed for Boeing 727, 737, and 747 aircraft. The task force will finish its work on the remaining aircraft in the fleet by the end of this summer.

In closing, Mr. Chairman, I want to stress that we are working on a variety of efforts to address the aging aircraft issue. This is a high priority issue with us. We are directing our efforts toward immediate corrective action for problems as they manifest themselves in our aging fleet. We are taking long range action towards the improvement of an airplane's tolerance to fatigue damage and corrosion, and in the improvement of inspection reliability including reducing reliance on inspections as a means of limiting the possibility of human error. We have also initiated cooperative efforts with industry in both the transport and commuter environment and are finalizing a comprehensive research and development program covering a variety of key areas. We appreciate the Subcommittee's continuing interest in and support of this vital safety program.

That completes my prepared statement, Mr. Chairman. I would be pleased to respond to questions you may have at this time.

Questions submitted by Senator Ford

1. Is it true that FAA regulations would allow a carrier to schedule a major maintenance overhaul piecemeal over a period of several months? Was this done with the Aloha Boeing 737 which was involved in the accident? Is this a practice used by many carriers?

ANSWER: Major overhauls, commonly known as "D" checks are performed on the average of every 10,000 to 20,000 hours of operation. These are major structural inspections during which the aircraft is opened up completely and inspected for structural damage and corrosion. It is common airline practice to segment the "D" checks. For example, an aircraft with a 20,000-hour interval may have the wings, fuselage, and empennage inspected 5,000 hours apart; however, each section is still inspected at the 20,000-hour interval. This saves downtime without degrading the quality of the inspection. The Federal Aviation Administration (FAA) does not object to this practice unless the number of segments are excessive or the system results in premature or late inspections. Aloha's "D" checks had too many segments, and we required Aloha to restructure its program.

2. Mr. Cosgrove of Boeing charged that the use of nonairline repair stations, who perform only those tasks specifically contracted for, can result in maintenance discrepancies being overlooked. Should there be a limit on the amount or type of maintenance work performed on older aircraft by outside contractors?

ANSWER: Nonairline repair stations are specifically certificated to perform certain types of maintenance and are subject to continuous FAA surveillance. They are responsible for the work contracted for but are also obligated by the Federal Aviation Regulations (FAR) to report any defects which they discover. Although an airline may contract work to a repair station, the airline is still ultimately responsible for the quality of the work regardless whether done by a repair station or a manufacturer's maintenance facility. We believe that if a repair station has been properly certificated, has adequate facilities, trained personnel, and a quality assurance system in place, there should be no restrictions on the type or amount of maintenance it has been certificated to do.

3. The average age of the commercial fleet is expected to increase to 15 years over the next decade. Do you believe FAA regulations and inspection procedures are sufficient to assure continued safety?

ANSWER: As the fleet continues to age and becomes more susceptible to fatigue and corrosion damage, we will have to improve our techniques for dealing with those hazards. We have long and short range research and development (R&D) projects dealing with a range of subjects such as advanced nondestructive inspection techniques and equipment, human factors impact on the inspection process, and improved corrosion control methods. We are studying current airline methods of structural inspection and their corrosion control programs. These efforts are all designed to enable us to fashion policy to deal with the aging fleet problem. So, to answer your question, we are in a continuing process of policy revision to deal with the changing environment and ensure the continued safety of our aircraft.

4. In 1986 the FAA convened a panel of experts to address the problem of multiple site damage (MSD) which is defined as cracking which occurs in the structure after extended service use. The task force recommended more tests for the manufacturers, more tear-down inspections for the carriers, and an FAA mandate of the MSD program. Has the FAA done this?

ANSWER: The FAA Northwest Mountain Region's Report on the Review of Large Transport Category Airplane Manufacturers' Approach to Multiple Site Cracking and the Safe Decompression Failure Mode was published December 18, 1986. One of the report's five recommendations addressed the MSD issue as follows:

a. Each manufacturer should establish a database to determine the threshold and severity of MSD by at least one of the following:

   1. Extended fatigue tests beyond the anticipated service life by one lifetime accompanied by teardown inspections.

   2. Teardown inspections of high-time service airplanes augmented by component tests, fatigue, and fracture analysis.

   3. Other FAA-approved means.

The FAA and industry have responded to these recommendations as follows:

- Boeing has developed fatigue test and teardown data on the B-727, 737, 747, 757, and 767 models. A report is in preparation on the Model B-737 and Boeing is still actively collecting fatigue data on the Model B-747.

- o McDonnell-Douglas has tested the DC-8 forward fuselage for 5 to 6 representative lifetimes to assure with high confidence that MSD would not occur in one lifetime. They tested the DC-9 fuselage to 208,000 cycles followed by a teardown inspection. They tested the DC-10 to two lifetimes and plan to take an inservice airplane for continued testing. McDonnell-Douglas' basic philosophy is to assure that MSD does not occur in one lifetime by testing two lifetimes. Lockheed has a similar philosophy and has tested the L-1011 to two lifetimes.

- o The FAA is currently preparing regulatory and policy documentation to mandate full-scale fatigue testing and teardown inspections for all aircraft designs. Industry has cooperated with the FAA in the testing and data collection on older airplanes; therefore, the FAA does not see a need for retroactively mandating such activity on those airplanes. However we will not hesitate to do so should the data provided by industry prove to fall short what we determine is needed to assure flight safety.

5. At the FAA's Aging Aircraft Conference in June 1988, participants agreed unanimously that "corrosion control techniques are not adequately addressed in the present maintenance programs." The conference also noted that about 95 percent of the problems with aging aircraft are due to corrosion. What has the FAA done to address this concern since June 1988?

ANSWER: As I mentioned earlier, a portion of our R&D program deals with finding improved methods for detecting, treating, and controlling corrosion. Much of this will involve technology transfers from the military and foreign countries. In addition to the R&D effort, we have a team of inspectors in the field visiting various airlines while "D" checks are in progress. The inspection team will evaluate the airline's corrosion control program relative to a model program containing the best elements of the aircraft manufacturer's program and those from other sectors of the industry. After the model program has been refined and improved, we plan to require operators to incorporate it into their programs.

6. Last year after ALOHA accident, the FAA said it would establish agency experts in nondestructive testing and inspection technologies, and would establish improved training programs for inspectors on these technologies. What progress has the FAA made in this area?

ANSWER: The FAA has established a National Resource Specialist (NRS) position for nondestructive testing. The FAA is actively seeking qualified applicants for this position. The NRS will be tasked with responsibility for the training of FAA inspectors in nondestructive testing and inspection techniques. The NRS will also oversee the FAA nondestructive test research and development activities which are now being initiated in support of the FAA's Aging Airplane Program. The FAA expects to select a person for this position by late September 1989.

We are in the process of updating our nondestructive testing course in Oklahoma City to include the latest state-of-the-art techniques and equipment.

Questions Submitted by Senator John Kerry

Mr. Broderick, it is my understanding that a number of companies -- some not directly related to the aviation industry -- are researching and developing advanced technologies which would greatly enhance the methods by which airplanes are tested for wear. Some of these companies are already doing business with the military. One such company, located in Massachusetts, has developed an advanced method of detecting metal fatigue in aircraft.

1. What is the FAA doing to appraise itself of the latest technologies being developed for aircraft testing?

ANSWER: The FAA has established a research program on aging aircraft. This program is described in document DOT/FAA/CT-88/32 (to be released in July 1989) which is currently in draft form. Included in this program is a review and development of existing and new technologies related to nondestructive test and inspection. The FAA intends to initially investigate existing technologies which are being used in various segments of the aircraft industry and in industries not directly related to aircraft. The FAA's intent is to gather application and reliability information on those various test methods and compile a reference manual or handbook for use by FAA and air carrier inspector personnel in applying those available technologies. As an adjunct to this effort the FAA intends to also investigate and publish information on the applicability and reliability of advanced nondestructive testing technologies to the aircraft inspection process.

2. The Department of Defense has obviously already availed itself of some of these new technologies. Has there been an effort by the FAA to stay appraised of those methods being effectively used by Defense to test aircraft?

ANSWER: The FAA has included in the research plan, described in the response to your first question, on aging aircraft a task to transfer technology from other Government agencies with substantial applied experience in the field of nondestructive testing. Methods used by the Department of Defense and other Government agencies will be assessed as a part of this research effort.

3. As Associate Administrator for Regulation and Certification, can you tell me what kind of time period we are looking at before the FAA can identify new testing technologies and effectively mandate their use by commercial carriers?

ANSWER: The FAA expects to publish a survey report on nondestructive testing equipment applicability, reliability, and usage by 1992. Implementation of this report will be considered at that time. Development of new technologies is not, sadly, a short term project. However, we will not be deterred in our efforts to develop these new technologies to slow.

4. Although the Aloha Air disaster was clearly the result of excessive wear to an aircraft, the more recent, and more deadly, mishap on the United 747 out of Hawaii may very well have been the result of a maintenance flaw. What can the FAA do to more effectively monitor and enforce maintenance standards and, perhaps, even improve them?

ANSWER: We are busy in several areas to deal with this problem. First of all, we are recruiting and hiring additional inspectors. We are increasing the numbers and types of surveillance our inspectors are required to perform. We are training our inspector work force on what to look for during their on-site visits, especially in the area of structural inspection techniques. We are sending teams of experienced inspectors and FAA structural engineers into the field to visit airlines and study the positive and negative impacts on the structural inspection process, including the areas of corrosion control, nondestructive testing techniques, airworthiness directive compliance, and human factor issues. We hope to fashion improved policy from these studies which will ensure the safety of our aging fleet.

Senator FORD. Thank you, Mr. Broderick. I was sensitive to your statement that said that this committee was a motivator and motivated you to do some things. I am glad that we can have some impact on the bureaucracy.

And it is very pleasing, I think, to the members of this committee that we can have some input into what is going on.

I have several questions, and we will try to hold them to about 10 minutes each. And some would like to move on to other items of business this morning, but this is vitally important and I intend to stay with it as long as necessary.

Mr. Broderick, recently the industry task force concluded that 20 years or a certain number of cycles, and we want to be sure that we understand a cycle is a landing and takeoff, whichever comes first, airline parts should be replaced instead of repaired.

Have you considered setting a life limit on an aircraft?

Mr. BRODERICK. Yes, we have considered that. And I wish the problem were that simple. As Senator McCain indicated, however, it is not.

What we have really done is set individual life limits on parts of aircraft. The design of aircraft and our understanding of the behavior of aircraft through service experience, shows us that we can successfully identify problems.

What our mistake had been in the past was that instead of eliminating the problem, what we did is look for initial cracking. We have decided now, since the Aloha accident, that we need to eliminate those weak links in the structure.

Effectively, what we will be doing is setting many life limits on an aircraft, the life limits being determined by either flight cycles, age, or just plain hours of operation, depending on what the limit is in the particular structural element.

Senator FORD. When you say structural element, could you give me four or five quick ones?

Mr. BRODERICK. Well, let us look at the fasteners in the 737. We had a particular problem that we knew cropped up with fastener holes being drilled in a certain way. We could eliminate that problem by drilling out the fasteners and replacing them with different kinds of fasteners, or we could monitor the holes for cracking.

The former is what we have elected to do now because the latter failed.

We may have parts of landing gear, parts of—details that fasten the stringers to the inner framework of the airplane. There are literally hundreds of critical, as they are called in the trade, design points on an airplane which can individually be analyzed, literally, down to every bolt in the airplane and every fastener in the skin.

It is those analyses that form the basis for the structural replacement programs that we are proposing.

Senator FORD. Some people say the industry does not have an aging aircraft problem, it has a maintenance problem.

On a scale of 1 to 10, would you agree or disagree with that statement?

Mr. BRODERICK. Well, I would not agree that we do not have an aging aircraft problem, but I would agree that we do have a maintenance problem. Maintenance is something that can only maintain the integrity of a design.

We have, as I indicated in my summary remarks, extraordinarily strict and stringent design criteria and good designs that come from the manufacturers. But you cannot rely on those designs to perform as intended without the best quality of maintenance.

We are learning that the human factor in some of these maintenance tasks, as indicated earlier, is one that has not properly been accounted for. And as you put it, I think, the numbing job of looking at literally thousands of fasteners on a cold rainy night up on a scaffold is something that is not well-suited to quality work. We have to look at these human elements in the maintenance program and improve them.

So I think we need to do work in both areas.

Senator FORD. Well, later today, Mr. Cosgrove of the Boeing Company will argue that to ensure the adequacy of airline maintenance programs, the FAA must move beyond paperwork towards the actual inspection of the aircraft.

What is your view of this idea? And would you support more hands-on inspections by FAA personnel? If this were done, what kind of resources would the agency need?

Mr. BRODERICK. Not only would I support it, we have already taken steps in that direction.

As indicated earlier, in the early-1980s we did have a shortage of inspectors, which is now being corrected.

With the added staff that we are getting this year—and that requested in fiscal 1990 and we plan the final increment of our multiyear buildup in 1991—with that staff comes a training burden,

which we will be addressing and are addressing right now, and the responsibility to do more of what we call over-the-shoulder work, actually looking at the inspections and maintenance being performed in the field by the airlines, and indeed, by the repair facilities.

We have changed our work program requirements for all of our field inspectors, effective the beginning of this fiscal year.

What we have now required is that for any repair facility in the area, inspectors must include actual on-site inspection of work being done for every airline and for every model of aircraft as a minimum in that facility. So we are doing that. It is an integral part of our planned work program buildup.

Senator FORD. What will be the additional personnel needed to fulfill this requirement in your mind?

Mr. BRODERICK. Well, I do not have a number for the additional personnel required to fulfill just that particular requirement, but I can tell you that in fiscal years 1988, 1989 and 1990, if you add up the budget totals, we are looking at about 900 additional inspectors, about half of them being maintenance inspectors who would be doing this kind of work from time to time.

Senator FORD. Is that adequate?

Mr. BRODERICK. I think it is. It is all calculated into a deliberately analytical staffing standard which takes into account every one of these tasks at the local level, and then adds up those requirements all around the country to come up with the total budget number.

We have gone from an availability-driven budget request, if you will, to a workload demand-driven budget request. Our best analysis of what is needed is the result of those requests today.

Senator EXON. Would you yield for a follow-up right there, Mr. Chairman?

Senator FORD. Sure.

Senator EXON. 900 additional people, is that what you indicated?

Mr. BRODERICK. Through 1990, that is correct.

Senator EXON. For maintenance now?

Mr. BRODERICK. No, that is for both maintenance and operations.

Senator EXON. What percentage is maintenance?

Mr. BRODERICK. About half are maintenance.

Senator EXON. What do you have now? Is that a fourth more or twice what you have now?

Mr. BRODERICK. That would be roughly a third more.

Right now, today, we have about, and I am talking about field inspectors, not support people like myself or administrative people——

Senator EXON. People out doing the job.

Mr. BRODERICK. Right. We have a little over 2,000 of them in the field today. We are adding in fiscal year 1989 about another 250 to 300, and the same in fiscal year 1990. And we did add 300 last year in fiscal year 1988.

It is about a 30 percent increase.

Senator EXON. So you are roughly moving from 2,000 to 3,000 by the end of the third year?

Mr. BRODERICK. That is correct.

And if I might, let me give you a longer-term perspective. The low point in our inspector staffing was in 1983. On September 30, 1983, I believe the number of inspectors we had in the field was only a little over 1,300. By September 30, 1991, our plan calls for nearly 3,000 inspectors. So it is in that period of time, about a seven- or eight-year period, more than a doubling of the actual field inspector workforce.

Senator FORD. Mr. Broderick, currently your agency allows individual carriers to develop and use their own maintenance programs, provided they meet, some minimum standards or minimum requirements by the FAA.

Why not require a single, standard maintenance program for all carriers?

Mr. BRODERICK. Actually we start out at an identical program for all carriers in the Maintenance Review Board documents that come with each airplane. We then look at the actual utilization that the airline is going to make of the airplane, its tooling, facilities and experience, and the environment, literally the geographic environment where it operates; we then factor all these things in and approve adjustments to the maintenance program, which takes specifics into account.

So we start from the same baseline, and though we have to call it a minimum, it is an extraordinarily high safety level that we require. We then tailor the program to the unique needs of each carrier, building in checks that are required uniquely for that carrier and not for others.

Senator FORD. I understand that your budget for 1990 requests $10 million for research into aging aircraft.

What areas will that be used for?

Mr. BRODERICK. The budget for 1990 actually has $10 million spread over, I think, 1989 and 1990, because we have already reprogrammed some money to get a head start on that.

We are going to be working in areas like fatigue cracking, corrosion protection, and non-destructive inspection. I think we have a particular responsibility to fund, at the Federal level, improvements in non-destructive inspection techniques and technologies that can be applied across the board not only in aviation, but in other fields.

We are also going to place a heavy emphasis, as I mentioned earlier, on the human factors of inspection and maintenance.

This is something that has never been studied before, and I think it is something that we can make a real contribution in: trying to understand how human performance or lack thereof adversely affects inspection programs and how we can improve upon human performance in these programs.

Those are some of the key areas that we will be focusing on.

Senator FORD. I want to ask one more question. Since my time has already passed, I will have some other questions that I will submit to you, Mr. Broderick, in writing, and ask for you to expedite answers to them.

Mr. BRODERICK. I would be pleased to.

Senator FORD. In describing the cause for an accident of rapid depressurization, an airline spokesman said the damage, and I quote, "did not occur at a normal failure point."

This seems to me to be the difficulty with damage to older airplanes. It does not occur where you expect it to occur because we have not had experience with it.

How can your agency deal with this type of problem?

Mr. BRODERICK. I would guess, without knowing, that that probably referred to the decompression of the Eastern Airlines aircraft——

Senator FORD. I think you are correct.

Mr. BRODERICK [continuing]. In West Virginia.

That was actually an accurate statement, because that accident was not related at all, as far as we know now, to the age of the aircraft. There was a, literally, a scratch mark that somehow got on the bottom of the top layer of a skin sandwich, a double layer of skin.

That scratch could not be seen once the skins were put together and should not have been there. During the repeated pressurization and depressurization cycles that the airplane underwent, it eventually failed.

That piece of structure is currently undergoing analysis by the National Transportation Safety Board to determine how many flexures, or how many cycles took place in order to try and infer whether that had been there since manufacturing or had somehow gotten there during maintenance.

The point of all of that long story——

Senator FORD. In other words, you are saying this is a piece of skin that was damaged and covered up?

Mr. BRODERICK. It was a unique failure having nothing to do with the age of the aircraft, and that is what that spoke person was referring to. Because we do know very well how structure ages and what points will fail, in what sequence, as aircraft age.

Senator FORD. Senator McCain.

Senator MCCAIN. Thank you, Mr. Chairman.

Mr. Broderick, let us start with the Aloha incident, if we could.

It is my understanding that all of the maintenance procedures required by the FAA had been complied with on that aircraft.

Is that accurate?

Mr. BRODERICK. That is what our records review has shown during the accident investigation.

Senator MCCAIN. And yet, obviously we had a very serious situation, with tragic loss of life.

What now are we doing that we could assure airline passengers that there would not be a recurrence of an accident on an airplane that had complied with all FAA inspection procedures?

Mr. BRODERICK. Sometime late this week or early next we will issue a final rule that requires replacement of the fasteners that caused the failure in that airplane on all 737s.

Those fasteners will be replaced, and that kind of failure will not happen again. Then we have taken that philosophy and applied it literally throughout all of the 737—well, all of the aircraft in our fleet, and we will be ordering similar changes in the future.

Senator MCCAIN. It is obviously speculative on my part, but it seems to me that, and you mentioned this in response to a question by the chairman, that geography may have had something to do with this corrosion. You are talking about an airplane that was

almost continuously exposed to salt air. And this—do you agree with that, that——

Mr. BRODERICK. Well, there is no doubt about it.

Senator MCCAIN. So, therefore, although we cannot have a single maintenance standard because, as you mentioned, of geography, could we have a single maintenance standard that takes into consideration the geographic location of these flight operations?

In other words, I am concerned, as I think many of us are, that different airlines have different standards, even though they may be in compliance with minimum FAA procedures. And I frankly am not totally satisfied that, particularly those airlines, and we know they are out there, that are marginally successful, that they may not be totally adhering to standards which more successful and larger airlines are employing.

Does that concern you?

Mr. BRODERICK. Well, we share your concern.

In the area of corrosion, we have actually formed three teams that are going to airlines inspecting in-depth the C and D checks, the annual and every four year heavy maintenance checks that are being undergone by aircraft that are particularly old.

What we are doing that for is to look at the behavior of aircraft, given a given airlines maintenance program, to try and understand the variations in performance, if you will, of the program, with respect to corrosion prevention.

We are going to do that across the entire fleet. Then we are going to rely on the industry, from whom you will hear later in the morning, to, after we have addressed the fatigue issues, and we completed that in the Boeing fleet, next attack the corrosion prevention and control issues.

Those two efforts will come together to generate, I think, the program that you had conceived. That is, an industry standard taking the best elements from everybody's corrosion program, an advisory circular that we will be then able to distribute and use as the basis for standardized corrosion control programs throughout the industry.

It is something that we had not done in the past, and we are not going to let it get ahead of us. We are going to do it now.

Senator MCCAIN. Well, frankly, I am very encouraged to hear that. Because I think it is important that we have, within the variables that are inherent with different operations and different areas and different climates and different numbers of takeoffs and landing, that we have a standard.

Mr. Broderick, in your testimony you stated that the manufacturers are offering training to FAA inspectors in the area of structural inspection and corrosion control.

Is the same being offered to all aircraft operators?

Mr. BRODERICK. Well, the manufacturers work very closely with the operators and provide them with large amounts of training and also field support.

We had asked them to provide special training for FAA inspectors that was a little bit different in its orientation. They have provided it at Boeing, and Douglas is in the process of developing the same kind of material.

98-741 0 - 89 - 2

So I think the answer is, in short, yes, they do offer similar kinds of training to customers.

Senator McCain. I have noticed that a number of industry-government groups in the area of corrosion, fatigue, engines, et cetera, have been coming up with various conclusions and ideas and recommendations.

Where does the responsibility lie to get the results of these various conferences and conclaves into the field?

Mr. Broderick. Well, I suppose it is fair to say that it lies right here, from the FAA viewpoint, from trying to gather the information and share it.

One of the program elements in our research and development program is what we call technology transfer, it is really just that. What I would like to see is a little bit more of the kind of NASA approach to annual symposiums in areas like human factors and aging aircraft.

Our meeting last year was very successful, and the R&D people assure me that they are going to repeat those meetings at approximately one or one-and-a-half-year intervals to try and build up a body of information and a network of experts throughout the country in that area.

Senator McCain. Can you tell this committee that you are confident that the additional 900 inspectors that you will have by 1991 will be sufficient, in your view, to get the job done. Ensuring that every aircraft in this country, U.S.-owned aircraft in this country, is properly maintained?

Mr. Broderick. Absolutely. We are not going to ask for fewer inspectors than the amount we think is necessary to do the job, Senator.

Senator McCain. Thank you.

I would suggest that, even in this era of severe budget constraints, you would find a very receptive audience here in this committee and in the Senate, if there is any additional measures that you think need to be funded.

There is a bit of a crisis in confidence out there today, Mr. Broderick. I do not want to use the word crisis, I think there is a deep concern amongst the American public today about the safety of the aircraft that they will be riding in.

And as you know, more and more Americans every day are flying on commercial airliners. And I think it is up to us as partners to make sure that they are totally reassured. Despite the fact that some accidents will take place, unavoidably and tragically so, that the maintenance of these aircraft is at its highest level.

And I hope that you and I and the chairman and the rest of this committee will be able to assure the American people of that.

Mr. Broderick. We will do our best, and we appreciate the support that we have gotten in the past.

Senator McCain. Thank you.

Thank you, Mr. Chairman.

Senator Ford. Thank you, Senator McCain.

Senator Exon.

Senator Exon. Thank you very much, Mr. Chairman.

Mr. Broderick, let me congratulate the FAA. You are seemingly moving on this problem. The line of questioning that I will follow

will try and probe as to whether or not you have gone in to all of the things that I think you should, and probably if you do not have the answers to some of these questions, I will understand, but it is to jar some thought and thinking as much as anything else.

This matter of the skins coming off of aircraft, has that happened elsewhere around the world? Is this unique to what we have experienced in the last 18 months?

Mr. BRODERICK. Well, I do not think it is unique. Although we do not have complete data, we do know of at least one other failure in the Far East that was, from a technical viewpoint, related to the Aloha accident, although it was not a survivable accident, and it was a cargo airplane.

But, nevertheless, the kind of damage that we have seen is not unique to the United States.

Senator EXON. It is unique to the United States, except for one other occurrence?

Mr. BRODERICK. No. The kind of damage we have seen is not unique to the United States. We have seen it, from a technical viewpoint, in other parts of the world, although the Aloha incident is the only one that occurred in precisely that manner.

Senator EXON. As a follow-up to that, tell me something about where this stress can appear. I guess it can be on anyplace on an aircraft. You know, the Aloha incident was a proportion of the front cabin, as I remember it. There was one in the rear or the tail section.

The recent United problem came in the cargo area, and then on up into the front compartment. There does not seem to be any pattern at all, and I suspect that that probably indicates that it is a general aging of the aircraft, except in the one instance where you said, and testified earlier to the fact that it was probably due to a fault in the original manufacture.

There is not any real way so far as you know now to say which part of the aircraft expresses, or has the most strain from being—the takeoffs and landings where they are pressurized. Is that right?

Mr. BRODERICK. Senator Exon, let me disagree. Let me say that each one of the three——

Senator EXON. You are not disagreeing. You are answering a question, and I have no—please do not presume that I have any advance knowledge. So you do not have to disagree with me, just tell me what you think.

Mr. BRODERICK. Okay. Each one of the incidents that you described is different. There is, in fact, predictability, very good predictability to where stresses are the heaviest, and where cracks will initially develop. Let me explain briefly the differences in each one of the three.

The Aloha incident arose because the fastener holes had sharp edges. Sharp edges generally provide points of concentration of stress, and are areas to look for, and in fact we had for years been inspecting that area for cracks. It is the fact that our inspections did not see cracks that obviously were pre-existing that caused us to be concerned about changing our program, with respect to Aloha.

With respect to the Japanese airplane, the JAL 747, there was actually an improper repair that had been done to the aft pressure

bulkhead. Perhaps the industry witnesses can give you more details, but to make a long story short, a number of fasteners were left off of this, causing extra stress on the remaining fasteners, which fatigued much more rapidly than in a properly constructed bulkhead.

Senator EXON. Was this the aircraft that flew out of control, and it finally crashed into a mountain?

Mr. BRODERICK. Yes, sir.

The third incident is still under investigation. The United Airlines 747 cargo door incident. From what we have seen so far, it appears that the cargo door did not fail in a structural sense, but failed in an operational sense. That is, it unlatched. And when it unlatched, it was such a large door, and the airplane was going so fast, that the wind literally ripped the door and surrounding structure off the aircraft.

So you see, we have three different things that went wrong in those cases. Only one of those was actually related to the age of the aircraft, and that is the Aloha tragedy.

Senator EXON. When aircraft are under production, I assume that you have inspectors there looking at the production line, you set certain standards, or do you not get involved until after the aircraft is completed and during the certification process?

Mr. BRODERICK. No, sir. We are involved from the very beginning. In fact, from the very conceptual design stage all the way through to literally taking the aircraft out of service.

Senator EXON. In our opinion, Mr. Broderick, are the same, or superior structurally sound principles used in foreign-made commercial aircraft as those that are under domestic manufacturing?

Mr. BRODERICK. In countries that produce airplanes and we have a bilateral agreement that recognizes their capabilities, the answer to that is yes. In countries that produce airplanes where we do not have a bilateral airworthiness agreement, we just do not know.

Senator EXON. Are there any aircraft now flying in the United States, or scheduled to be purchased for use in the United States with countries that we do not have the arrangements that you just referred to that convinces your agency that they do meet the same standard?

Mr. BRODERICK. No, sir. We will not allow a U.S. airline to buy an airplane, and put it in service if we have not given that airplane type certification. The only way to get a type certificate on a foreign-produced airplane is through the bilateral airworthiness agreement.

Senator EXON. When one airline transfers or sells an aircraft, sometimes it is an aging aircraft, to another commercial airline, is there any certification process with FAA at that time?

In other words, if company A sells an aircraft to company B, is the FAA involved in that transfer from an inspection or safety standpoint?

Mr. BRODERICK. We may or may not be specifically involved. What I can tell you is that every airline has a process that they have had to submit and get approved by the FAA that deals with exactly the steps involved in bringing an airplane from outside the company into the company, and introducing it into service.

Those steps are very detailed, and as implied by your question, can involve a great deal of expense and documentation for proper past maintenance.

In some cases, for example, we will not allow parts that are fairly substantial—engines, landing gear, and things like that, to be used in U.S. service, because their past history is unknown.

Senator EXON. Are you satisfied that we are doing enough in that area as of now?

Mr. BRODERICK. Yes, sir. Our tehniques are quite satisfactory, and our requirements are very stringent.

Senator EXON. With the development of newer aircraft, I assume that we are going to be going more and more to the fly-by-wire technique that we use on military aircraft today, which as I understand it, means that a pilot is really flying a computer, and the computer is flying the aircraft, as opposed to the more traditional rods and wires, and cables, and so forth.

As we move into that area of fly by wire, are we potentially experiencing more or less stability of the survival of the aircraft in future years, when we come into the problem with stress points, skin ripping off, and so forth and so on.

Put it another way. Does flying by wire compromise, in any significant fashion, the ability of the airplane to fly, as opposed to the older system of cables and more manual movements?

Mr. BRODERICK. Not at all, sir. As a matter of fact a good argument can be made that a properly designed fly by wire system can actually make flight safer, because of the extra capability that it gives the pilot in the airplane.

Senator EXON. Thank you, Mr. Broderick. Thank you, Mr. Chairman.

Senator FORD. Thank you, Senator Exon.

Let me ask you one final question. Senator McCain may have thought of some others.

We have a backlog on purchase of airplanes, which is creating some of the safety problem. We cannot get planes delivered, so that gives some of our people an excuse to go overseas and buy other airplanes, which I do not like. I think they ought to buy them all right here.

But in discussing with the down-home types, you know—not all the engineers and PR types—they indicate to me that at some point you can rebuild an aircraft, probably at two-thirds of the cost, and it would come out, virtually, as a new aircraft. Is there anything to that?

Mr. BRODERICK. Well, it is certainly possible to do that with smaller aircraft. We have seen restorations of small aircraft that make them as good, or even better, than new.

But when you talk about the complexities of a large transport aircraft, it becomes less and less feasible to do that, because of just the tremendous amount of structural hardware that is in place. Another concern that one would have if the airplane has been sitting for any length of time, would be corrosion.

So I do not see that as being something that is a feasible alternative.

Senator FORD. You could not strip it down to the skeleton and rebuild it from there out? Then a rebuilt aircraft would cost two-

thirds or 75 percent of what a new aircraft would cost, and it basically would perform then as a new aircraft.

Mr. BRODERICK. In theory you could, but in practice I do not think that is a practical alternative.

Senator FORD. Well, let us get practical here this morning.

Senator, do you have anything else?

Senator MCCAIN. Just one, Mr. Chairman.

Do you have any ideas on what we do about foreign carriers that fly in and out of the United States?

Mr. BRODERICK. You mean in terms of maintenance? We do require, through a recent rule change—well, it is actually not that recent. For some amount of time now, we have required them to follow the International Civil Aviation Organization Minimum Maintenance Standards. We have to recognize——

Senator MCCAIN. Those are somewhat different than ours, aren't they?

Mr. BRODERICK. They are somewhat different, and of course, ICAO, the organization that develops those standards and recommended practices, does not have any enforcement authority.

What we have to recognize is that a foreign airline is literally that: it is foreign. And I like to tell people that one of the best ways to ensure that the maintenance quality is good is not to look at necessarily the name on the airplane, but look at the flag on the tail. If it is a U.S. flag on the tail, you can be assured that it has gotten the U.S. maintenance and oversight that sets such a high standard of aviation safety for our industry.

Senator MCCAIN. Perhaps, also, that would be a reason for more American citizens to fly U.S. flag carriers. I hope someday the FAA gets into the issue of the quality of the food, but I am sure that is a subject for a different hearing, I am sure, Mr. Chairman.

Senator FORD. You know it is strange when you get swiss cheese, a slice of bologna with relish on that, and then another slice of cheese on top of that, and brown and white bread. It tends to make one wonder, doesn't it?

Senator MCCAIN. I think that is called a snack.

Another hearing. Thank you, Mr. Chairman.

Senator FORD. Another hearing. Thank you, Mr. Broderick, we are delighted to have you here today, and thank you. There will be some questions, maybe from other members of the Committee, in writing to you, and I hope you will respond in a timely manner.

Mr. BRODERICK. We will be happy to.

Senator FORD. Thank you very much.

Mr. BRODERICK. Thank you, Mr. Chairman.

Senator FORD. Next, we will have Mr. Kizer, Vice-President of Engineering and Maintenance, Air Transport Association of America. Mr. Cosgrove, Vice-President and General Manager of Engineering Division, Boeing Commercial Airlines, and Dale S. Warren, Vice-President for Engineering, Douglas Aircraft Company of McDonald-Douglas Corporation.

Welcome gentlemen, and if there is no objections, we will proceed with each of you making a statement. We will start with Mr. Kizer here, move to his left, and at the end of each statement, at the end of all three statements, Senator McCain and I, and others who might come will pose questions for individuals.

So if that is all right with you, you may proceed.

STATEMENT OF CLYDE R. KIZER, VICE PRESIDENT, ENGINEERING, AND MAINTENANCE, AIR TRANSPORT ASSOCIATION OF AMERICA

Mr. KIZER. Thank you. Mr. Chairman, and members of the Subcommittee. I am Clyde Richard Kizer, Vice-President Engineering and Maintenance, Air Transport Association of America.

ATA is pleased to detail the process which the airlines, the manufacturers, and the government utilize to deal with the issues of concern to you today.

Our full testimony, submitted for the record, describes the aging phenomenon, the underpinning regulatory process, the role of the manufacturers, the philosophy of the airline maintenance programs, and in particular, the recent activities of the ATA/AIA Airworthiness Assurance Task Force and its recommendations.

It further describes the system that provides for progressive airworthiness safety nets, and concludes that the system, rigorously applied, will continue to protect the safety of the traveling public.

It should be understood that the term "aging aircraft" is a misnomer. From the time an airline aircraft enters fleet service, it is inspected and maintained, and refurbished. By the time it has reached 10 to 15 years of age, thousands of components and upwards of tons of material have been replaced.

In order to assure airworthiness, an aircraft in commercial airline service is remanufactured as it progresses in age, and if the appropriate life-extending measures are taken, it can be flown safely, almost indefinitely.

I realize this is not apparent to those who try to make the analogy to an older automobile, but automobiles are not constructed, inspected, maintained, or remanufactured in the same manner as an airline aircraft.

The Office of Technical Assessment completed a study for Congress on the safety of commercial aviation in the United States in July of 1988. That study acknowledged the collective efforts of all components of the industry in achieving a safety record that has continued to improve with time to provide one of the best records in the world.

This study and other facts support the conclusion that inherent design considerations for our fleet are sound, and that current maintenance requirements are capable of retaining the soundness of those designs.

All of the industry responsible for the airworthiness of our aircraft believe there is no evidence that justifies a definitive limit to the useful life of current aircraft, based on structural considerations.

Despite the best efforts of dedicated and well-qualified people, failures do occur. Recent structural failures have mobilized the industry in an unprecedented effort that brings together our best technical skills to reassess basic philosophies, practices and procedures to verify their validity.

Immediately following the FAA International Conference on Aging Aircraft of June 1 through 3 of 1988, ATA Airlines, and air-

craft manufacturers initiated a program to coordinate the collective technical expertise of the air transport industry to stress the objectives established during that conference.

The resulting organization, known as the Airworthiness Assurance Task Force, involves international experts representing the airlines, air frame manufacturers, regulatory agencies, NASA, and professional aviation mechanics from the United States, European, and Asian nations.

Task force studies to date indicate that the following fundamental basic requirements for maintaining the airworthiness of an aging fleet are well known and sound: preventative maintenance program which focuses on the determination of why something fails, instead of when it fails, and continuous monitoring of the aircraft, using all appropriate inspection and testing methods.

In addition to these well-established requirements, we have added a new dimension to our maintenance program philosophy: mandatory replacement, or modification of parts and material, in lieu of continuing inspections.

The task force is now attempting to define a standard program of effective corrosion, prevention and control for use by the airlines and manufacturers.

In summary, our testimony describes a system of progressive airworthiness safety nets provided by the following.

The basic airworthiness of an aircraft is provided by the manufacturer through effective design and production techniques which assure durability, strength, damage tolerance and corrosion prevention through compliance with FAA regulatory requirements.

The retention of inherent aircraft structural integrity and reliability is provided through conscientious application of an effective, continuing, preventative maintenance program by the operator and monitored by the FAA.

In-service problems are addressed by service bulletins issued by the manufacturer and/or airworthiness directors issued by the FAA.

Periodic life extension, and/or performance improvement programs are initiated by the operator, frequently in conjunction with manufacturer recommendations, to provide enhanced integrity, reliability or performance.

Recommendations from the Airworthiness Assurance Task Force provide an additional measure of safety by reestablishing the original aircraft structural configuration through material replacement, or by providing improved structural configuration through modification with better materials.

These recommendations, coupled with a continuing research and development program dealing with, among other things, inspection techniques, human factors, and better use of automated information systems, along with periodic reviews, such as the Airworthiness Assurance Task Force, will provide the necessary longer-term stimulus to staying ahead of problems that might develop.

Mr. Chairman, the system for assuring continued airworthiness of our airline fleet is sound. All three parties involved in the system, government, manufacturers and the airlines, are working together to improve our collective understanding of why and how recent structural failures occurred, and to recommend all actions

necessary to provide the safest system of air transport humanly possible.

We request your support in our efforts.

[The statement and questions and answers follow:]

STATEMENT OF CLYDE R. KIZER
VICE PRESIDENT - ENGINEERING & MAINTENANCE
AIR TRANSPORT ASSOCIATION OF AMERICA
BEFORE THE SENATE COMMITTEE ON COMMERCE, SCIENCE
AND TRANSPORTATION, SUBCOMMITTEE ON AVIATION
ON AGING AIRCRAFT, APRIL 11, 1989

Mr. Chairman, and members of the Subcommittee, I am Clyde Richard Kizer, Vice President, Engineering and Maintenance, Air Transport Association of America (ATA). ATA is pleased to appear before you today on behalf of our member carriers to address congressional concern about the safety and airworthiness of older transport aircraft.

What I would like to do today is detail the process which the airlines, the manufacturers, and the government utilize to deal with the issues of concern to you today. I will discuss the aging phenomena, the underpinning regulatory process, the role of the manufacturers, the philosophy of airline maintenance programs, and, in particular, the recent activities of the ATA/AIA Airworthiness Assurance Task Force and its recommendations. I will describe the system that provides for progressive airworthiness safety nets and conclude that the system - rigorously applied - will continue to protect the safety of the traveling public.

At the outset it should be understood that the term "aging aircraft" is a misnomer. From the time an airline aircraft enters fleet service it is inspected, maintained, and refurbished. By the time it has reached 10-15 years life, thousands of components and literally tons of material have been replaced. In order to assure airworthiness, an aircraft in commercial airline service is remanufactured as it progresses in age. If the appropriate life extending measures are taken, it can be

flown safely almost indefinitely. I realize this is not apparent to those who try to make the analogy to an older automobile or other off-the-shelf consumer products, but consumer products are not constructed, inspected, maintained or remanufactured in the same manner as airline aircraft.

The Office of Technology Assessment (OTA) completed a study for Congress on the safety of commercial aviation in the United States in July of 1988. That study acknowledged the collective efforts of all components of the industry in achieving a safety record that has continued to improve with time to provide one of the best records in the world. It is significant that 1988 marked one of the best records for safety ever achieved by the U.S. airlines.

There is concern that the airlines have reduced funding for maintenance as a result of the economic pressures of deregulation. Airline maintenance activities were not subject to deregulation, and the OTA analysis demonstrated that the airlines increased their dollar contribution to the maintenance effort consistently over the five years preceding its report. That report additionally concluded that the industry experienced no degradation in aircraft reliability over that same period.

These facts support the conclusion that inherent design considerations for our fleet are sound and that current maintenance requirements, conscientiously applied, are capable of retaining the soundness of those designs. There is no evidence that justifies a definitive limit to the useful life of current aircraft based on structural concerns.

THE AGING FLEET

The relatively brief history of the air transport system in the United States has been marked by exceptional technological advances in transport category aircraft. Those advancements were driven by the need to develop this nation's air power capability during the two world conflicts of this century. For many years the competitive nature of those technology advancements dictated frequent fleet replacement by U.S. airlines in order to take advantage of the rewards of the market place. The ability to fly higher, faster and farther with greater efficiency has always provided the means to extend the reach of the aviation industry.

The first jet transport, the British Comet, was touted as a breakthrough in technology for the traveling public. Despite a well publicized and significant design deficiency, the average life of that aircraft was more than 13 years, and the oldest Comet remained in service for 19 years. The DC-7, which immediately preceded the first commercial jet, remained in U.S. passenger service for just over 10 years. Technology, not concern for age, drove the DC-7 out of the competitive arena.

Although not always readily apparent, aircraft retirement decisions by the airlines have almost always been driven by marketplace considerations rather than by intrinsic characteristics of design. Such decisions are usually based on one or more of the following factors:

- Noncompetitive operating costs
- Noncompetitive performance
- Excessive fuel costs
- Noncompetitive technology
- Noise constraints.

The current fleet of U.S. airline aircraft has an average age of 12.7 years. Approximately one fourth of the operating fleet (about 960 aircraft) is 20 years or older. Recent aviation forecasts predict the useful life of currently operating aircraft in the range of 25-30 years.

AGING PHENOMENA

When discussing aging aircraft, we must generally do so in empirical terms since no criteria exists which allows identification of a particular aircraft as "old." Basic principles help define the aging process as it applies to airplanes, but as with humans, some aircraft show their age prematurely while others are indistinguishable from their newer counterparts.

Aircraft structural engineers and operators agree that aircraft show the effects of age in relation to years, flight hours and flight cycles. In addition, the effects of the operating environment, specifically temperature and humidity, can alter the aging process significantly and must be taken into account in both design and operational considerations.

Fatigue and corrosion are the primary problems associated with aging aircraft. Corrosion is time and material sensitive, while fatigue is a function of flight hours, to some extent, and more directly, to flight cycles. In this context a flight cycle includes the takeoff, full pressurization and subsequent landing phases of flight, while full pressurization means the maximum compression of cabin air allowed by normal aircraft design limits.

These issues must be addressed by the manufacturer in the selection of aircraft materials, as well as in the working of that material during the production process and the design of

the aircraft for damage tolerant structural integrity. In addition, corrosion control methods include the application of appropriate preventative substances to aircraft materials during production.

Since aircraft structures begin to deteriorate from the time they are first worked in the production process, an effective preventative maintenance program must begin with the acceptance of the aircraft. That program also must be revised through the years to reflect the way the aircraft is used, the environment in which it operates and the aircraft's structural condition as revealed in repetitive maintenance inspections of increasing intensity.

REGULATORY PROCESS

The fundamental issue of concern before us today is the airworthiness assurance of this nation's commercial fleet of aircraft. Three parties are involved: FAA, which is responsible for the regulatory framework within which industry designs, builds and maintains the airline fleet, the manufacturers and the airlines. The basis for the airworthiness of that fleet is established in the rules of the Federal Aviation Administration. Federal Aviation Regulations Part 25 defines the airworthiness standards for transport category aircraft, applicable to the design of aircraft, and FAR 121 establishes certification and operation requirements for commercial operators of large aircraft.

In addition to establishing the basic regulatory requirements, the Federal Aviation Administration provides a critical surveillance function for both the manufacturer and the operator to assure compliance with their responsibilities.

These three parties, the regulatory authority, the manufacturer and the operator form the essential elements of airworthiness assurance for the air transport system. Since their responsibilities are interdependent, that relationship is frequently likened to a "three legged stool." Each leg must operate effectively to provide the level of safety essential to our system.

Thus, principles of airworthiness depend on the establishment of regulatory requirements applicable to design and production of aircraft to meet stringent safety criteria. These aircraft must then be operated and maintained to standards which assure the viability of the design features.

AIRWORTHINESS RESPONSIBILITIES

The manufacturer is responsible for basic aircraft design considerations which assure airworthiness by providing stability, control and structural integrity consistent with regulatory requirements. The objectives of strength, durability, damage tolerance and resistance to corrosion serve as the basis for airworthiness with respect to structural integrity. These considerations will be reviewed by the testimony of others during these hearings.

The maintenance plan for a new aircraft type is developed in accordance with a maintenance program planning document. FAA manufacturers and airlines collaborate in this effort. The most recent version of this maintenance program planning document was prepared by an ATA sponsored maintenance steering group and is known as MSG-3 to reflect the third such effort. MSG-3 maintenance programs incorporate decision logic based on the consequence of failure, the distinction between maintenance

required for safety and economic reasons, and the treatment of hidden functional failures. MSG-3 provides task oriented logic and includes the effects of multiple failures and damage tolerance rules. It also incorporates a supplemental structural inspection program for high time aircraft. MSG-3 programs are based upon the concept of "Reliability Centered Maintenance," i.e., programs that focus on demonstrated maintenance needs for systems and components rather than on arbitrary removal or repair time intervals.

The responsibility of the operator is to provide a continuous preventative maintenance program which can adapt the original maintenance plan to sustain, or even improve, the structural integrity and reliability of the original design.

Required maintenance intervals traditionally have been short for new design aircraft and systems. Intervals are extended as experience with the aircraft builds. The extension of individual airline maintenance intervals is predicated on the demonstration of consistent levels of safety.

The significance of higher levels of hours and cycles on a particular aircraft fleet are evaluated on an on-going basis by means of a Supplemental Inspection Program that extends to all significant structural elements of an aircraft. This program, cooperatively developed by airline operators, manufacturers and the FAA, makes available to every participant the cumulative results of the industry's inspection and testing programs. This data is also used by each aircraft manufacturer to prescribe programs of additional inspections which ensure prompt detection

and correction of any new problems. These programs use a combination of visual and sophisticated non-destructive inspection methods such as X-ray, radioisotope and eddy current to detect defects.

As aircraft age, the combined effects of fatigue and corrosion have frequently dictated a reduction in maintenance intervals to address specific problems affected by age and use - a reversal of the process that occurs after an aircraft type is introduced into service. One major airline has estimated that airframe overhaul maintenance costs associated with aging structures of the oldest fleets might increase 10-25% in comparison to earlier overhaul costs.

The air transport industry has gathered its collective expertise frequently in the past to address common technical issues. These collective efforts have often addressed concerns over the aging fleet of that era. These activities have included an industry study of the fatigue effects of pressurization as well as the development of the creative and proactive Supplemental Structural Inspection Program. That program allows us to determine maintenance problem areas before they become endemic.

Aircraft do not age in quantums. They do so on a flight by flight, hour by hour basis. The fleet is monitored and maintained by airlines on that same basis, so at any point in time we can, and do, collectively review a comprehensive cross-section of that fleet as an indicator of its health.

The aircraft manufacturers conduct periodic international fleet surveys to assess the condition of high time aircraft from their product lines. This valuable undertaking provides the most comprehensive assessment of the effects of environment,

operational requirements and individual airline maintenance efforts as they impact the aging process.

In addition to airline and manufacturer activities, the FAA is responsible for auditing the fleet condition on a daily basis. In the past, personnel reductions have impaired the capability of the FAA to conduct on-scene aircraft surveillance. However, resources redirected by Congress and management actions by the FAA have augmented the safety inspector workforce.

AIRWORTHINESS ASSURANCE TASK FORCE

Despite the best efforts of dedicated and well qualified people, failures do occur. The failures are related to both individual and system errors. Significant failures are most often the result of a combination of low probability events which defy prediction. In any event, recent structural failures have mobilized the industry in an unprecedented effort that brings together our best technical skills in an effort requiring that we reassess basic philosophies, practices, and procedures to verify their validity.

On June 1-3, 1988 the FAA conducted an International Conference on Aging Aircraft to address technical issues relating to the continued airworthiness of aircraft and engines. In addition, the Conference addressed research and development issues, human factors and non-destructive inspection concerns. The primary focus at that Conference was an exchange of views and discussion about concepts most productive in assuring the airworthiness of the aging fleet.

It was obvious after the first day that the technical issues that were raised could not be fully developed or explored within the limits of the three day Conference. Consequently,

representatives of the membership of the ATA and Aerospace Industries Association (AIA) compiled eight recommendations which addressed those issues, including the establishment of a task force to study aircraft airworthiness concerns and make recommendations to assure continued safety. (Attachment I).

Immediately following that Conference, ATA airlines initiated a program to coordinate the collective technical expertise of the air transport industry to address the objectives established during the Conference. The resulting organization, known as the ATA/AIA Airworthiness Assurance Task Force, involves international experts representing the airlines, airframe manufacturers, regulatory agencies, NASA and professional aviation mechanics from the United States, European and Asian nations. When establishing the objectives of this effort and identifying a candidate fleet sample of aging aircraft, it was decided to consider, arbitrarily, aircraft greater than 15 years in age and/or those with service experience exceeding about 60% of design economic flight hours or flight cycles.

The task force is comprised of approximately 150 of the best qualified technical experts in government and the air transport industry. The direction and coordination of this effort is provided by a steering committee headed by Robert Doll, Vice President - Technical Services, United Airlines. Other members of the steering committee are: Dave Kruse, Vice President - Maintenance and Engineering, American Airlines; Julian May, Vice President - Engineering, Delta Air Lines; Leroy Keith, Manager - Aircraft Certification, FAA; Bob Goodrich, Director - Flight Standards, FAA; Ben Cosgrove, Vice President - Engineering, Boeing Commercial Airplane Company; Dale Warren,

Vice President - Engineering, Douglas Aircraft Company; Sam Venneri, Director - Materials and Structures, NASA; David Wadsworth, Executive Director - Professional Aviation Mechanics Association; David James, Head of Structures and Materials, Civil Aviation Authority (United Kingdom); Jean-Yves Le Lann, Deputy Vice President - Engineering, Air France; Peter Bashford, British Aerospace, and Clyde Kizer, Vice President - Engineering and Maintenance, ATA. (Attachments II and III).

Three working groups, led by the ATA airline representatives on the steering committee, provide the detailed technical effort necessary to address several short-term goals selected to reflect the current condition of the fleet and provide a basis for recommendations for mandatory action that will assure the airworthiness of older aircraft.

One of the important short-term objectives involved a review of service bulletins applicable to specific model aircraft (such as B-737, DC-9 and BAC 1-11) to determine the need to require repair, modification or replacement action based on industry experience.

Service bulletins are issued by the airframe manufacturers to address industry-wide maintenance problems encountered during the operation of specific model aircraft. The basis of the service bulletins under review was originally economic in nature. Service bulletins which address safety problems are incorporated in airworthiness directives (ADs) issued by the FAA which require mandatory action by the operators of the affected aircraft. The review of service bulletins for the task force is meant to pool the collective experience of the major airlines operating specific model aircraft. That collective knowledge

provides a basis for task force recommendations requiring repair, modification or replacement rather than continued inspection for certain service bulletins.

The Boeing Working Group has completed their detailed review of 225 existing service bulletins for 727, 737 and 747 aircraft and have recommended that 150 of those service bulletins be adopted by the FAA for mandatory action known as "termination." The results of the Douglas Working Group should be announced the end of May. The International Working Group should complete their service bulletin review by June or July.

Additional important short-term objectives include:

- a review of corrosion prevention and control requirements to determine if certain corrosion control principles should be applied by all operators;
- a review of existing maintenance plans to determine the desirability of recommended limits to variations from the basic plan;
- an assessment of the effectiveness of the industry's age-related supplemental structural inspection program (intended to detect and control potential problem areas before they become endemic);
- and a review of currently approved repairs to determine the technical merit for additional action.

The coordination of working group actions and schedules and the pursuit of long-term objectives are the responsibility of the steering committee. Longer term objectives include:

- consolidation of human factors principles and research and development as they apply to aircraft design, maintenance and inspection;

- prioritization of research and development applicable to airworthiness of older aircraft;
- review of training and qualification standards for aircraft mechanics and inspectors;
- recommendations concerning the need for revision of aircraft maintenance communications systems;
- recommendations concerning fatigue testing of aircraft.
- a possible recommendation for a continuing structural review to be conducted, perhaps on an annual basis.

Task Force studies to date indicate that the following fundamental basic requirements for maintaining the airworthiness of an aging fleet are well known and sound:

- A preventative maintenance program which focuses on the determination of why something fails instead of when it fails.
- Continuous monitoring of the aircraft using all appropriate inspection and testing methods.

In addition to these well established requirements we have added a new dimension to our maintenance program philosophy:

- Mandatory implementation of selected service bulletins, in lieu of conducting continuing inspections.

RESEARCH AND DEVELOPMENT REQUIREMENTS

In addition to mandatory implementation of Service Bulletins, the need for R&D activities has been identified. These needs range from technology transfer to pure research and include the following:

- Inspection techniques
- Inspector training and qualification
- Human factors
- Automated data gathering and transfer

CONCLUSION

In summary, progressive airworthiness safety nets are provided by the following:

- The basic airworthiness of an aircraft is provided by the manufacturer through effective design and production techniques which assure durability, strength, damage tolerance and corrosion prevention through compliance with FAA regulatory requirements.
- The retention of inherent aircraft structural integrity and reliability is provided through conscientious application of an effective continuing preventative maintenance program by the operator and monitored by the FAA.
- In-service problems are addressed by service bulletins issued by the manufacturer and/or airworthiness directives issued by the FAA.
- Periodic life-extension and/or performance improvement programs are initiated by the operator, frequently in conjunction with manufacturer recommendations, to provide enhanced integrity, reliability or performance.
- Recommendations from the Airworthiness Assurance Task Force provide an additional measure of safety by re-establishing the original aircraft structural configuration through material replacement, or by providing improved structural configuration through modification with better materials.

- **These recommendations, coupled with a continuing Research and Development Program dealing with, among** other things, inspection techniques, human factors, and better use of automated information systems, along with periodic reviews such as the Airworthiness Assurance Task Force, will provide the necessary longer term stimulus to staying out ahead of as yet unknown problems.

Mr. Chairman, the system for assuring continuing airworthiness of our airline fleet is sound. All three parties involved in the system -- government, manufacturers and airlines -- are working together to improve our collective understanding of why and how recent structural failures occurred and to recommend all actions necessary to insure no similar recurrence. We request your support of our efforts.

I will be pleased to answer any questions you may have.

Air Transport Association ata OF AMERICA

1709 New York Avenue, NW
Washington, DC 20006-5206
Phone (202) 626-4000

May 11, 1989

Honorable Wendell H. Ford
Chairman, Aviation Subcommittee
Senate Committee on Commerce, Science,
and Transportation
United States Senate
Washington, D. C. 20510-6125

Dear Senator Ford:

The following is submitted in response to your letter of April 18, 1989 which included additional questions for the Air Transport Association witness, Mr. Clyde Kizer, about the continuing airworthiness of the U.S. air transport fleet:

1. Question:

You stated that recent aviation forecasts predict the "useful life" of currently operating aircraft to be in the range of 25-30 years. How safe is "useful" aircraft life?

Answer:

The basic requirement of each carrier's maintenance program is that it must be effective in preserving the same level of reliability and airworthiness that was designed into each aircraft at production. There can be only one level of safety, and it must be consistently applied to all aircraft. An aircraft is no longer useful if it fails to meet the requirements for safety.

2. Question:

What kind of maintenance do the air carriers perform now that will detect or defer aging of the aircraft?

Answer:

The progressive preventative maintenance program approved for each carrier must be adaptable so it can reflect the condition of the aircraft at each progressive check. As an aircraft, or fleet of aircraft, shows evidence of age-related deterioration, the maintenance program is adjusted

accordingly to provide increased frequency and scope of inspection and/or repair. Wherever fatigue, corrosion or damage is found in an aircraft the source of the problem must be determined and corrective action taken using approved techniques.

An industry program of sampling and surveillance, known as the supplemental structural inspection program (SSIP), insures that the condition of the fleet is monitored continuously. In addition, each operator is kept abreast of the findings, and corrective actions undertaken, by means of service letters, service bulletins, service difficulty reports, airworthiness directives and other forms of communications between the carriers, manufacturers and the FAA.

Planned maintenance activities include a series of inspections, preventative actions (such as corrosion prevention, anti-ice protection, etc.), and repair. Inspections include visual and non-destructive techniques (such as ultrasound, eddy current, X-ray, etc.). The appropriate technical device is used to detect the presence of fatigue, corrosion or damage in known problem areas. Historically, visual inspections have been most effective in detecting "first time" problems, such as fatigue cracking or corrosion in areas of the aircraft where they were not experienced before.

As aircraft are inspected, their condition is monitored by the carrier, by FAA representatives and, in most cases, by aircraft manufacturer representatives. The results are reported to the industry so that all are aware of problem areas as they develop and can plan appropriate corrective responses. Corrective actions may be initiated by an individual carrier, by the manufacturer or by the FAA. In many cases, all three organizations will be involved in the determination of the type and timing of that action.

Preventative action includes the addition of material or modification of design to prevent known problems from occurring. These actions are accomplished in accordance with airline, manufacturer, or FAA directives.

Until recently, the FAA permitted the airlines to take an "inspect and repair" approach to maintenance. Recommendations of the industry's airworthiness assurance task force will result in airworthiness directives that will require corrective action in the form of material replacement, or modification, for known problem areas at a specific threshold in each aircraft's operating life. These actions will restore the aircraft structure to its original condition through the replacement of material, or provide improved structural integrity through modification.

3. Question:

Some are concerned that airline mechanics fear pressure from the airlines and therefore may fail to report damage or cracks when seen. Do you believe this to be true? If so, can you suggest any solution?

Answer:

Each person involved in the air transport system has a responsibility to protect the safety of the aircraft in that system. The men and women of the air transportation industry are acutely aware of their moral, legal and professional responsibilities regarding the safety of the system and they take those responsibilities seriously. The safety record for the industry reflects the effectiveness with which they meet their responsibilities.

Each person licensed by the government is subject to disciplinary action by the FAA in the event he or she fails to maintain accepted professional or legal standards. Thus each certificate holder risks the loss of his/her livelihood for failure to report known aircraft problems.

The FAA has established a "hot line" for anonymous reports by anyone who believes that illegal or unethical activities are taking place.

The sum of the requirements and actions listed above indicate that individual responsibilities with respect to safety are being met at all levels. Were that not true the effects would be adversely reflected in safety statistics and/or the FAA would be flooded with calls from concerned employees about actions which compromise safety and legality.

I do not believe that an environment exists which forces people to compromise their principles in order to continue their employment. That potential does exist, but I believe that there are adequate safeguards to prevent such abuse. I believe that the men and women at all levels of responsibility in this industry want to do the right thing and that the record shows they are very successful at doing so. I believe that the system occasionally fails because of human error, not because of malicious intent.

4. Question:

The Aging Aircraft Conference report states that "mechanics of limited experience are utilized to conduct the inspection of complex structures . . . and industry sampling results indicate that human inspection results vary from 60% to 80% accuracy." No one wants to fly on a plane on which the inspection was 60% accurate What is the airline industry doing to train mechanics?

Answer:

Definitive data on the accuracy of human inspection capability is sadly lacking. In any event, that capability is not as good as the industry would like. Inspection intervals are predicated on the presumption that defects may be missed. Intervals are based on known fracture propagation rates to ensure detection before problems become critical. Thus our programs are based on known limitations concerning human inspectors and are designed to provide as close to 100% assurance of detection of problem areas as possible.

Much could be done to improve the reliability of our inspection methods. The Airworthiness Assurance Task Force is attempting to address this issue on several fronts:

- The Task Force will make recommendations concerning standard training and qualification requirements for inspectors. That effort is underway in coordination with the ATA Non-Destructive Testing Committee.

- The task will make recommendations concerning the training and qualifications of mechanics in conjunction with the requirements for completion of approved airframes and powerplants schools.

- The Research and Development Working Group of the Task Force will make recommendations concerning short term/long term development of NDT capabilities to enhance detection of cracks and disbonds. This will include the development of automated assistance to current technologies, microprocessor/computer aid to current technologies, image enhancement/hardcopy capability for current technologies, transfer of existing technologies from other applications and development of new technologies.

- Human factors will be addressed in cooperation with FAA efforts under Dr. Shepard. These will include aspects of selection, job definition, tool and aircraft design with human factors considerations, and communications that improve understanding.

- The whole scope of communications will be reviewed from esoteric concepts such as simplified English to the more basic requirements for training and hands-on experience for those who write the work instructions for others to interpret (this includes FAA, manufacturers and airline engineers).

We recognize the limitations to our current practices. Our policies and procedures are developed to accommodate those limitations, but we seek to improve our effectiveness through the activities listed above.

5. Question:

The Wall Street Journal reports that normally a jet's maintenance costs rise about 2% a year. I would expect air carriers' maintenance costs to increase as the fleet ages. How does the maintenance percentage of airline operating costs compare from 1979 to 1988?

Answer:

The fleet maintenance and total operating expenses have been increasing over the last 9 years (1979-1988) as shown in Attachment 1. Maintenance expense has been increasing at a compound annual rate of 10.2% while the total operating expense has been increasing at a slightly lower annual rate of 9.5%. As a share of total operating expense, maintenance expenses have increased from 9.1% in 1981 to 11.9% in 1988.

6. Question:

You have identified a number of R&D activities that you believe must be accomplished. What are the airlines doing in response to this desired objective?

Answer:

In addition to the items listed in #4 above, the following areas are being explored with respect to R&D:

- Working in conjunction with NASA, DOD, FAA and the aviation industry as a whole, the Airworthiness Assurance Task Force is surveying the potential for development of more effective corrosion control processes and procedures. This will include products as well as programs (such as the successful concepts employed by the U.S. Navy).

- Repair techniques are being studied for R&D consideration. This is especially true for composite material repair processes. NASA research in composite structures also includes maintenance and repair requirements based on ATA and AIA requests.

- R&D applications for aircraft fatigue testing will be considered by the task force in light of the conclusions of the International Conference on Aging Airplanes.

- Actual flight load determination and analysis is being considered for further R&D.

- The airlines are participating in the FAA Research Advisory Committee. The Advisory Committee was created by the Aviation Safety Research Act of 1988 which requires increased FAA research in several key areas including aging aircraft. The committee holds its first meeting on May 25, 1989.

- In testimony to the House Committee on Science, Space, and Technology Subcommittee on Transportation, Aviation and Materials, ATA recommended that the FY '90 FAA aging aircraft research budget be increased by $7.0 million to $12.5 million.

We hope these responses are specific to your questions, but will be happy to provide greater detail, or further explanation as necessary. We appreciate the opportunity to comment and review our activities and procedures as they apply to continuing airworthiness issues.

Very respectfully,

William J. Burhop
Sr. Vice President -
Government Affairs

Attachment 1

U.S. SCHEDULED AIRLINES
Maintenance Cost Analysis
($ Millions)

Attachment 1

	Maintenance Expense	Total Operating Expense	Maintenance Share of Total
1979	3,028.7	27,027.6	11.2
1980	3,464.8	33,949.4	10.2
1981	3,559.6	37,117.3	9.6
1982	3,373.5	37,141.1	9.1
1983	3,562.8	38,643.3	9.2
1984	3,933.9	41,673.5	9.4
1985	4,491.9	45,238.2	9.9
1986	5,528.6	49,201.8	11.2
1987	6,153.6	54,561.1	11.3
1988	7,251.7	61,114.7	11.9

Source: U.S. Dept of Transportation

Senator FORD. Thank you very much.
Mr. Warren.

STATEMENT OF DALE S. WARREN, VICE PRESIDENT FOR ENGINEERING, DOUGLAS AIRCRAFT CO., McDONNELL DOUGLAS CORP.

Mr. WARREN. Thank you, Mr. Chairman and Senator McCain. I am Dale Warren, a vice president from Douglas Aircraft Company. I appreciate this opportunity to testify before this subcommittee. I have submitted a formal statement, and I would like to highlight some key points at this time.

Senator FORD. It will be included. All statements will be included in the record.

Mr. WARREN. Thank you, sir.

The manufacturers, operators and regulatory agencies have consciously managed the aging fleet of aircraft for over 20 years. Tremendous advances have been made during that time in all of the relevant technologies.

Two extraordinary actions have been taken by Douglas and Boeing. The first is extended service life testing, and the second is in-service evaluation of the current fleet by manufacturing design teams.

Douglas purchased one of the oldest DC-9s out of service and conducted extended service life testing to a total equivalent of nearly 70 years of service.

After testing a tear-down inspection of 14,000 fastener holes indicated that the useful service life had not yet been reached.

In the second area, Douglas has the equivalent of a six-man team working half time in the field reviewing the performance of Douglas-built airplanes in service. Attention is given to both fatigue and corrosion. Through this program, engineers personally see the performance of their designs in service and some design changes and maintenance recommendations have resulted from this action.

Industry-agency cooperation is the key to successful management of the aging aircraft fleet. The current Aging Aircraft Task Force is an outstanding example of industry-agency cooperation. The principal activity to date has been identification of service action terminations for high time aircraft. Corrosion control, life limits for repairs, human factors and non-destructive inspection are also under consideration.

The model groups for the DC-8, the DC-9 and the DC-10 are in the final stages of service bulletin review and should complete their recommendations this month. The remaining actions should be completed this summer.

There is concern that a significant number of aircraft are operating beyond their design life goals. A summary of the status of the Douglas models is summarized in the formal statement. The DC-9 is conspicuous. 584 DC-9s—that is more than half of the DC-9 fleet—are operating beyond the original design goal. However, none of them is operating beyond the test-supported life established by the special DC-9 life extension test that I mentioned earlier.

Corrosion is a special concern in that it is not predictable, and there is no such thing as a design life for corrosion. Historically,

corrosion accounts for 80 percent of the repair and replacements of structural parts. That trend is down, due to improved alloys and corrosion protection and also longer operating life.

Two key factors emerge from the latest studies. Good alloy selection and corrosion protection systems are fundamentally important. Second, even the best-manufactured product with the latest alloys and the latest protection systems require diligent inspection and maintenance. And even more stringent programs are required for older aircraft with higher sensitivity.

I have a high level of confidence in extended life programs. The system for maintaining safety with extended service life is basically sound. Some refinements require further attention and are under consideration by the industry task force, and some special funding may be required for FAA and NASA participation.

[The statement and questions and answers follow:]

TESTIMONY OF

DALE S. WARREN
VICE PRESIDENT AND DEPUTY GENERAL MANAGER
FOR
STRATEGIC BUSINESS AND TECHNOLOGY DEVELOPMENT
DOUGLAS AIRCRAFT COMPANY

I am Dale Warren, Vice-President, Deputy General Manager for Strategic Business and Technology Development at Douglas Aircraft Company, a component of the McDonnell Douglas Corporation. My qualifications include BS and MS degrees in Civil Engineering from the University of California at Berkeley, specializing in structures, and thirty-five years of experience in design, development and in-service support of aircraft structures at Douglas. I have been actively involved in the Douglas participation in industry-agency actions regarding ageing aircraft for thirteen years.

GENERAL COMMENTS

The manufacturers, the owner-operators, and the regulatory agencies are dedicated to a safe commercial air transportation system and have been agressively proactive in managing the ageing fleets of commercial aircraft for at least twenty years. The first documentation of this activity was a set of FAA Advisory Circulars developed in the late 1960s and identifying special inspections appropriate for high-time commercial transports. These were written when the first US jet transports were about ten years old and clearly destined to be in service for an unprecedented period of time.

Tremendous advances have been made since then in all of the relevant technologies. The fundamental mechanisms of fatigue and fracture have become more clear, and the processes of design have been upgraded to reflect this new understanding. Design methods have been improved, largely through the use of large scale computers with the result that the structure and the design environment can modelled with far more accuracy. Testing capabilities have been improved, even to the point of allowing

realistic spectrum loading of large scale structures. Non-destructive testing procedures have been developed to a high level of reliability. Improved protection systems have been developed and alloys have been selected to reduce the potential impact of corrosion.

The regulations for certification and maintenance of commercial transports have been upgraded to take full advantage of these developments. The last generation of transports have been designed and certified to the new regulations using the latest technologies. In addition, the principal models of the current fleet have been re-evaluated on the basis of the latest technology by the manufacturers, and supplementary inspection programs have been established to assure safety during extended service.

Two extraordinary actions have been taken by McDonnell Douglas and Boeing. The first is extended service life testing and the second is in-service evaluations of the current fleet by manufacturer design teams. Douglas purchased one of the oldest DC-9s out of service and conducted extended service life testing to a total equivalent of nearly 70 years of service (208,000 total of service and simulated flight cycles). After testing, a teardown inspection of 14,000 fastener holes indicated that the useful service life had not yet been exceeded.

In the second area, Douglas has the equivalent of a six-man team working half-time in the field reviewing the performance of Douglas-built airframes in service. Attention is given to both fatigue and corrosion, and high time aircraft are given priority subject to access during heavy maintenance. This first-hand feedback is additive to the normal reporting by operators and field service representatives. Some design changes and maintenance recommendations have evolved from this activity.

The current Ageing Aircraft Task Force is an outstanding example of industry-agency cooperation. The activity is led by the aircraft owner/operator community, and participation is

international. The principal activity to date has been to identify Service Bulletins that should have mandatory closing action rather than continuing inspection for high-time aircraft. Other major areas under consideration by the Task Force include corrosion control, life limits for repairs, and R&D into human factors, non-destructive inspection, and full-scale fatigue testing.

DESIGN GOALS AND LIFE EXTENSION EVALUATION

The table below summarizes the status of the Douglas Commercial jet fleet relative to design life goals and test supported life.

DAC FLEET STATUS IN FLIGHT CYCLES

MODEL	NO A/C BUILT	NO A/C ACTIVE	DESIGN LIFE GOALS	NO A/C EXCEED	TEST SUPPTD LIFE	NO A/C EXCEED
DC-8	556	347	25,000	57	70,200	0
DC-9	976	920	40,000	584	104,000	0
MD-80	569	567	50,000	0	75,000	0
DC-10-10	138	134	42,000	0	42,000	0
DC-10-30/40	306	295	30,000	0	30,000	0

The following observations are noteworthy.

1. More than 1/2 of the DC-9 fleet (584 aircraft) is operating beyond the original design goals, however none of these aircraft are operating beyond the test supported life. This extended coverage is the result of the special DC-9 life extension test conducted during the last few years.

2. The 57 DC-8s that are operating beyond the design goal are not beyond the test supported life. This extended coverage is due to a re-evaluation of the original testing and and is largely the result of removing some of the conservatism from the test results.

3. The data in the table summarizes status in flight cycles. Status in flight hours is generally less significant but is

important for the DC-10-30/40 (intercontinental version). Several of these aircraft are operating beyond the design goal and test supported life, both in terms of flight hours. The original test results are under review and additional extended coverage is expected.

The Supplemental Inspection Program is also a powerful tool for evaluating the real life of an airframe. The current fleet is the best data source for estimation of remaining life and the approach is to identify focused inspections and then statistically evaluate both positive and negative findings to anticipate behavior and commit proper actions.

Douglas is emphasizing support of safe extensions of life for the current fleet because the airframe manufacturers are unable to satisfy the demand for additional lift, and early retirements will restrict air travel.

CORROSION AND FATIGUE FINDINGS

Two different surveys (about 10 and 15 years ago) indicate that about 80% of the airframe replacements/repairs are due to corrosion related degradation. Future surveys should show a reduction in the relative significance of corrosion because of the use of improved protection systems and less sensitive alloys, and because fatigue should become more significant as the fleet average age increases. Even with these trends, corrosion will continue to be a significant and perhaps dominant factor in airframe integrity. Recent but relatively limited data, including design team inspections of in-service performance, highlight several key factors.

1. Good alloy selection and protection systems are fundamental.
2. Special attention is required for bilge areas; provisions for drainage and ventilation must be reliable.
3. Areas under galleys and lavatories also require special attention.
4. Other areas also require attention, such as drip lines in overhead structure subject to condensation.

5. Even the best manufactured alloy/protection system requires diligent inspection and maintenance. More stringent inspection and maintenance is required by owner/operators of older aircraft with higher corrosion sensitivity.

LEVEL OF CONFIDENCE IN EXTENDED LIFE PROGRAMS

The system for maintaining safety with extended service life is basically sound. The respective roles of the manufacturers, the owner/operators, and the regulators is relatively clear and generally understood. Some refinements require further attention and are under consideration by the Ageing Aircraft Task Force.

1. Completion of the service action termination lists for high time aircraft.
2. Review/upgrade the current recommended maintenance programs.
3. Assess ageing of structural repairs and set standards.
4. Review/upgrade the current corrosion prevention programs.
5. Review/upgrade the Supplemental Inspection Document (SID) programs.
6. Recommend and guide further research and development into several areas, including human factors and non-destructive inspection.

Continuing support by the Aviation Subcommittee of the Senate Committee on Commerce, Science and Transportation is needed in the form of resource authorization for proper participation by the FAA and NASA. The current program for specialized training of FAA inspection personnel by the manufacturers is particularly worthwhile. The NASA is the logical organization to manage any special R&D programs.

TASK FORCE STATUS ON DC- AIRCRAFT

Model groups are in the final stages of the DC-8, DC-9, and DC-10 Service Bulletin reviews, and should complete their recommendations this month. A special joint meeting with selected representatives of the Boeing model groups was held two weeks ago to cross-check recommendations for consistency. Review of corrosion is started and should be complete in June. Review of SID programs, repairs, and maintenance programs have been started and should be complete in July.

RESPONSE TO ADDITIONAL QUESTIONS FROM SENATOR FORD

by Dale S. Warren

1. QUESTION: Your testimony says that non-destructive testing procedures have been developed to a high level of reliability, and that the regulations for certification and maintenance of commercial transports have been updated to reflect this. Does this also apply to FAA inspectors? Are they knowledgeable in these techniques?

ANSWER: The procedures have been greatly improved - the FAA is now in the process of upgrading their staff. Douglas is currently working with FAA to present an in-depth training program for about 300 FAA inspectors. The goal is to complete this training by fall. Boeing is also coordinating with FAA for a similar program.

2. QUESTION: You mention that 57 DC-8s are operating beyond the original design and test life for that aircraft, and that this extension is due to a "re-evaluation" of original test data which removes "conservatism" from the tests. What does that mean and why does it worry me to hear it?

ANSWER: First to clarify the status, (a) 57 DC-8s are currently operating beyond the original design and test goals, (b) the test results are being re-evaluated in the light of the actual service usage patterns, and (c) the re-evaluation is expected to show that the actual life is greater than originally required.

Three different factors are considered in the re-evaluation.

1) At least in the first 10-20 years of service, the typical flight duration averaged significantly more than the estimate used in the fatigue design and testing. Some elements of the DC-8 airframe are sensitive to both flight cycles and flight time and a more accurate assessment of actual usage may change the forecast of remaining life.

2) Typical aircraft loading (both fuel and payload) was conservatively estimated in the original design process. Actual usage patterns are now available and are being used in the re-evaluation. As a rule of thumb, a 10% change of stress can change life by a factor of two - so a re-evaluation using more realistic loading histories may significantly change the forecast of remaining life. The effect of these two factors is significant enough that the USAF tracks the utilization of each individual aircraft of certain types and adjusts the mission utilization to maximize overall life of the fleet.

3) The reference tests did not necessarily end in failure of the test specimen - the typical test only shows that the design is good enough, but does not show reserve strength or life at the completion of the test. The original test specimens are not available for further testing, however, the data base available for reference has been expanded greatly in the last thirty years and has value in assessing the remaining life of these airframes.

The DC-8 was our entry in the new and hostile environment of commercial jet transports, and we were very conservative in many aspects of the design, specifically fatigue integrity. The DC-9 was designed with similar conservatism and the extended service life test program demon strated a fatigue life much greater than the original design requirement. On this basis, we expect that re-evaluation of the DC-8 tests will show a significant increase in economic life.

This concept may tend to cause worry because it inspires you to envision something akin to two sets of books. Please be assured that the work is being done by highly capable and dedicated engineers with no personal motivation other than pride in their work. I would be very happy to make this work available for on-site review by any impartial expert.

Senator FORD. Thank you very much, Mr. Warren.
Mr. Cosgrove.

STATEMENT OF BENJAMIN A. COSGROVE, VICE PRESIDENT AND GENERAL MANAGER, ENGINEERING DIVISION, BOEING COMMERCIAL AIRPLANES

Mr. COSGROVE. Good morning, Mr. Chairman, Senator McCain. I am Ben Cosgrove from the Boeing Company. I am vice president of engineering.

And, as you well know, aging aircraft is a complex issue and the focus of concern and interest, and I would like to take a few moments to clarify some of the technical aspects of the situation.

I think it was mentioned by Senator McCain that the calendar age of a commercial airplane is only important when it is combined with two other factors and total flight hours accumulates and, secondarily, the flight cycles that accumulates.

Now, when you take these three factors together to determine the condition of the airplane, you also have to take into account, the level of maintenance and the inspections needed on the airframe.

Safety is not compromised merely due to age, if proper maintenance has been performed. The safety of airplanes depends on an in-place safety system comprised of three major participants, and that system in turn depends upon the skill, knowledge and diligence of those participants. They are the airlines who operate, inspect and maintain the aircraft; the regulatory agency, whether it be the FAA or foreign regulatory agency establishing rules and ap-

proving designs and approving and monitoring the compliance with maintenance plans; and the manufacturers who design, build and provide in-service support.

In our 1986 testimony, Boeing stated that it intended to expand its knowledge of aging aircraft; and to this end, why, we started the two-year aging airplane fleet evaluation in June of 1986. We visited 46 operators in 25 countries and looked at 74 high-time aircraft while they were going underneath the heavy maintenance checks. Each operator was briefed as to the findings, and semiannual reports were mailed to all the airlines and to the FAA and the regulatory agencies.

What we found in general was that the aircraft structure and systems were in good condition, and adequate maintenance was being received, except in a very few cases. Fatigue cracking was generally found in areas where it might be expected. Corrosion, however, was observed to be insidious and detrimental to fatigue characteristics.

As a result of some of these inspections, why, we came to the conclusion that as an airplane exceeds its design goals, some structure should be modified or replaced rather than inspected.

In addition to the aging fleet survey, fatigue testing and tear-down inspections have been conducted on older airframes to gain insight on the problems on high-time aircraft with repairs and service-caused defects.

In 1987, Boeing purchased a damaged 737, 20 years old with about 42,000 flights on it—excuse me, 42,000 hours and about 60,000 flights, and we added another 70,000 flight cycles to see how the airplane would perform to a total of 130,000 cycles. At the completion of the test it was disassembled and inspected, and we found that the aircraft structure was in good condition, with very little corrosion.

Also, a retired 747 with 25,000 flight cycles with about 18 years was acquired, and we are currently testing to simulate an additional 20,000 flights, which is about 20 years more. We expect this test to be completed in 1990. The wing and empennage of that particular 747 are in a tear-down program now, and the fuselage will be put into the program as it completes its fatigue testing.

As you know, after the Aloha incident and the June 1988 FAA symposium, the ATA formed a steering committee to address the issue of operating a fleet of older aircraft, and that working group looking at Boeing models consists of 15 airline people, the FAA and Boeing specialists. And they have been meeting monthly to look over high-time—bulletins for high-time aircraft modifications. And we submitted those modifications and recommendations to the FAA on the 31st of March of this year.

That group is now developing corrosion-directed inspection and prevention programs and is reviewing current maintenance practices and supplemental structural inspection programs. These activities will be completed this year, 1989.

In concluding my remarks, I would like to make a few points. The manufacturers are constantly improving designs, but aircraft cannot be considered indestructible. We think some emphasis should be placed on certain key areas.

Good maintenance results from adequate and proper maintenance practices and skill levels. So far, we found the airline maintenance to be good.

However, we are concerned about the airlines' maintaining adequate engineering and maintenance staffs and the difficulty of transferring aging aircraft knowledge when high-time aircraft are transferred and about the number of airplanes being maintained by non-airline maintenance stations.

In regard to the FAA, we believe they have done a good job in monitoring the airline maintenance systems through the paperwork system. But, as we noted in 1986, we believe they should inspect the physical condition of aircraft. They are attempting to do this, but I am concerned that they may not have the resources or the experience required as they expand.

One of the actions that we took at Boeing was we offered a series of classes for over 300 FAA principal maintenance inspectors, and these classes are aimed at improving the inspectors' understanding of supplemental structural inspection programs and gives them a feel for our experience on corrosion and fatigue, and so they will kind of know where to look.

We think the manufacturers need to continue the hands-on approach with the airlines, but we do not think that the manufacturers should be considered the maintenance surveillance and enforcement group. We think that is a proper role for the regulatory agencies and the FAA.

We, the manufacturers, need to improve communication with the airlines and regulatory agencies regarding clarity and timeliness of the service bulletins.

And, with that, Mr. Chairman, I think that we will end up with a system, as far as we are concerned, that will end up by making the aircraft industry as safe as it has been in the past and probably safer. So that our view is that the Aging Aircraft Committee formed by the AT has done a marvelous job, and we want it to continue. Thank you very much.

[The statement and questions and answers follow:]

98-741 0 - 89 - 4

STATEMENT OF BENJAMIN A. COSGROVE, VICE PRESIDENT/GENERAL MANAGER, ENGINEERING DIVISION, BOEING COMMERCIAL AIRPLANES, THE BOEING COMPANY

Mr. Chairman, Honorable Committee Members, I am Ben Cosgrove, Vice President and General Manager of the Boeing Commercial Airplanes Engineering Division. I thank you for this opportunity to address the aviation subcommittee on the issue of aging aircraft.

A great deal of interest in the issue of aging commercial jet transport fleet has been expressed by you, the Congress, the national media and the public in general. First, let me assure you that the technical problems associated with the aging of aircraft structure are understood. With the dedicated support of the airlines, the FAA, and the manufacturers, commercial jet aircraft can be operated safely far beyond their original design life goals.

Design life goals are economic objectives established by the manufacturers. During that life an operator can expect reliable service with normal maintenance practices. When the goals are exceeded, maintenance requirements may increase. The actual service age of the aircraft does not jeopardize its safety when adequate maintenance practices and procedures are followed.

In testimony before the Senate Aviation Subcommittee in April 1986, the safety system of the air transportation industry was described in some detail. However, since it is relevant to this testimony today, a brief description seems to be in order. Our national air transportation safety system is composed of three major participants: the manufacturers who design, build and support aircraft in service; the airlines who operate, inspect and maintain the aircraft; and the Federal Aviation Administration who establish rules and regulations, approve the design and maintenance plans, and monitor airline maintenance

performance. The safety of commercial transport aircraft depends heavily on this system, and the system depends upon the skill, knowledge, diligence and cooperation of all participants.

My testimony today will involve discussions of what Boeing, as an active participant of the safety system, has done and will continue to do in the areas associated with aging aircraft issues. Activities include surveying of older airplanes; conducting fatigue testing, disassembly inspection of airplanes retired from airline service, and supporting industry task group activities. I'll finish the testimony with some recommendations.

BOEING AGING FLEET SURVEYS

The average age of aircraft in the world airline jet transport fleet has increased from 8 years in 1980 to 12 years in 1988. This upward trend in airplane operating age is forecasted to continue and reach an average age of about 15 years by the year 2000. In the 1986 testimony, it was stated that Boeing intended to expand its knowledge of aging airplanes and of those factors influencing maintainability of structures and systems. To this end, a 2-year Aging Fleet Evaluation Program was implemented in 1986. The objectives of this program were:

- To gain an engineering assessment of the conditions of older aircraft with emphasis on structures and systems.
- To assess the effectiveness of Boeing corrosion prevention features and other corrosion control actions taken by the operators.

- To acquire additional fleet data that will be used to improve maintenance recommendations and promote improved design of new airplanes.

A representative cross section of both foreign and domestic operators, with aircraft approaching the economic design life goals, were invited to take part in the program. A total of 43 airlines in 24 countries participated in the program by allowing Boeing to complete thorough surveys of 74 of the oldest 707, 727, 737 and 747 aircraft.

Survey teams were dispatched to inspect aircraft during scheduled heavy maintenance checks when the airplane floor and interior were removed. Six engineers experienced in structures, systems, and maintenance recorded their inspection results in survey documents. These documents are unique for each airplane model and cover up to 350 structures details and 150 systems items. The survey teams paid special attention to the condition of the primary structure such as wing and empennage box structures, major bulkheads and fuselage monocoque structure, and primary systems such as landing gear, flight controls, and avionics. The survey also included a review of airline practices regarding airplane usage, maintenance program and dispatch reliability.

At the completion of each survey, the operators were briefed by the teams on their findings. Operator response to the program has been favorable and with complete cooperation.

When the survey teams returned to Boeing, all significant findings were reported and assigned to appropriate Boeing organizations for necessary action. Over 220 action items were identified during these surveys. These actions included revisions to existing service bulletins, release of new service bulletins and changes in the design of aircraft currently being manufactured. Semi-annual reports were released to all operators of Boeing aircraft and the FAA.

Considerable variation was seen in the airplane condition and airline maintenance procedures, such as inspection intervals and corrosion prevention measures. The condition of structures and systems was excellent and adequate maintenance was being received, except for a few cases. A number of findings have emerged:

- Corrosion

  The most significant findings are related to the prevalence of corrosion in the fleet, and the extent varies considerably between operators and within an operator's fleet. Manufacturing standards have evolved gradually over the years and corrosion protection systems vary between models and also between different versions of the same model. A special Boeing task force is now developing a consistent package of corrosion prevention procedures for all models. Aircraft that were subject to corrosion prevention programs from the time of entry into service exhibit minimal corrosion. If preventive actions are delayed, repair actions may be required as soon as five years later.

- Fatigue Damage

Most fatigue damage observed during the surveys occurred in previously known areas and required action was already identified in existing Boeing technical publications. None of the new fatigue problems encountered were of immediate safety of flight concern.

- Service Bulletin Compliance

  Service Bulletin compliance may be achieved by special inspections and/or specific aircraft modifications. Airlines frequently choose to institute a program of special inspections. Compliance through aircraft modifications varies with the airline and ranges from a low of 20% to a high of 80%.

- Maintenance Programs

  Maintenance programs tend to focus on flight hours or calendar time. Short flight operations can result in inspection intervals that are too large. Consideration of flight cycles, or takeoffs and landings, is important for timely fatigue damage detection. Some maintenance programs being used on older aircraft may not recognize the significance of age.

One of the actions taken by Boeing as a result of our observations during the surveys is that we are conducting a series of three day classes for over 300 FAA Principal Maintenance Inspectors (PMI's). These classes are aimed at improving the inspectors' understanding of supplemental structural inspection programs for finding new fatigue problems, corrosion prevention and control procedures, and nondestructive inspection techniques. These

classes should help to provide more consistency between airline maintenance programs which are reviewed and approved by the PMI's.

FATIGUE TESTING AND DISASSEMBLY INSPECTIONS

In addition to fatigue tests conducted on new airplane models, similar tests have been conducted on older airframes to gain in-sight into the problems that might be experienced on high-time airplanes with repairs and service-caused defects.

A 737, with 60,000 flights and 42,000 hours accumulated during 18 years of service was damaged in an accident in late 1986. It was purchased by Boeing for detailed structural examination and fatigue testing. Structural load tests were completed that simulated the loading an airplane would experience if it performed a very high number of flights. An additional 70,000 simulated flight cycles, equaling a total of 130,000, were applied to the fuselage to study the effects of extended pressurizing and depressurizing on the passenger cabin structures.

A retired 747 with 25,000 airline flights was acquired and added to the program in 1987. The fuselage structure is being subjected to additional simulated flight cycles to explore extended usage beyond the design life goal of 20,000 flight cycles. Our goal is to test this airframe for an additional 20,000 flights, or a total of 45,000 flight cycles with completion by early 1990.

Boeing has conducted several disassembly inspections of high-time aircraft as a part of a continuing assessment of structure. These inspections permit a detailed examination of structural performance and provide useful information for forecasting future structural maintenance requirements.

Major disassembly inspections, supplementing normal fleet surveillance activities, have been conducted on 707 and 727 models in the past. In support of the increased number of airplanes being used beyond their design life goals, Boeing is conducting additional inspections of airframes retired from service.

The 737 purchased for the extended pressure cycling was subjected to a detailed inspection. The structure was found to be in good condition with very little corrosion. While of no immediate safety concern, some new findings emerged. Most findings, however, on this airframe were in previously known problem areas. They have been corrected in subsequent derivatives, and service bulletins and retrofit kits have been made available to operators.

The 747 being used for the extended pressure cycling of the fuselage is currently being disassembled for detailed wing and empennage inspection. The fuselage will be inspected after completion of flight cycle testing now in progress.

INDUSTRY TASK GROUP ACTIVITIES

An Air Transport Association steering committee was formed in August 1988. This committee is made up of industry representatives from airlines, airworthiness authorities, manufacturers and other knowledgeable organizations including NASA. Their primary activities have centered on supporting development of maintenance programs uniquely tailored to address operation of airplanes that are beyond their original economic design life goals.

Working groups have been formed to address each airplane model. The Boeing groups comprising 15 airline, FAA and Boeing specialists and have been meeting monthly in Seattle to:

- Select service bulletins for high-time airplane modification based on potential for safety problems, probability of occurrence and difficulty of inspection. Working group recommendations were delivered to the FAA on March 31, 1989.

- Develop corrosion directed inspection and prevention programs based on fleet data.

- Review adequacy of current maintenance programs being applied to the aging airplanes. This will include review of maintenance intervals and phased versus major checks.

- Assess structural repair quality relative to long-time operation.

The majority of these activities are planned for completion this year and will result in maintenance recommendations that will support continued safe operation of aging jet transports until their retirement from service due to economic considerations.

RECOMMENDATIONS

We feel that each of the major participants in the air transport industry should examine their contribution to the safety system, particularly as it relates to the airworthiness of the aging fleet.

- **Airlines**

  Generally we have seen good inspection and maintenance programs by the airlines. However, considerable differences exist as reflected by the effectiveness of these programs. In some cases maintenance items are deferred longer than we think desirable. Minimum industry standards should be maintained to ensure fleet safety.

  Airlines need to provide proper technical capability by maintaining adequate engineering and maintenance departments. If proper technical staffs are not available, the airlines are unable to properly use technical information provided by the manufacturers. Typical problems that can occur are improper repairs, lack of proper maintenance records, and failure to recognize the importance of flight cycles, flight hours and calendar time when developing structural inspection programs.

One particular concern we have is the transfer of older airplanes from experienced airlines to ones with different experiences and technical resources. As a particular airplane model matures in an airline's fleet, the maintenance and engineering people come to know the airplane and learn to deal with the aging process. When these older airplanes are transferred to other airlines, the experience and knowledge of the older airplanes is difficult to transfer. The ability to deal with the aging process may be reduced. Diligence must be exercised to ensure that all maintenance programs effectively address the aging aircraft issues.

Non-airline repair stations are being increasingly relied upon to perform major maintenance. We have observed a few cases where these repair stations perform tasks only in accordance with the specific statement of work detailed in the contract work package. This can result in discrepancies being overlooked during inspections. There are cases where these repair stations do not receive sufficient technical information from the airlines and they may lack adequate knowledge of an airplane type.

- FAA

Historically the FAA has done a good job of ensuring the adequacy of the airline maintenance programs. However, their surveillance is primarily through monitoring of paperwork rather than observing the physical condition of the airplanes. We believe they should inspect airplanes. The FAA is expanding their role to include more comprehensive airplane surveillance, but we are concerned that they

may not have the resources and experience base necessary to do this job particularly in the next two to five years.

The recent assessment of large fines by the FAA and the public outcry that follows in the press when something is done incorrectly does little to improve safety. Routine use of such penalties tends to drive problems underground and com nication in the industry suffers. However we do feel that if an airline deliberately ignores safety then fines are certainly appropriate.

The number of aircraft being operated for a short time period by one airline and then transferred to a different airline is growing. These aircraft may not be receiving adequate maintenance and because of this the average condition of the fleet could deteriorate. The FAA should establish requirements for continuity in maintenance programs for such aircraft.

The FAA should establish a policy that ensures that used airplanes exported out or imported into the U.S. are in an acceptable condition and are accompanied by appropriate maintenance and airworthiness records.

- Manufacturers

The manufacturers need to spend more "hands on" time at the airline facilities as was done in recent Aging Fleet Survey Programs. A better understand the effectiveness of recommended maintenance programs and the overall condition of the fleet will develop. Boeing is

committed to continuing this program. However, the manufacturers should not be considered the primary surveillance group to confirm that airline inspections and maintenance are being performed satisfactorily. Boeing recognizes this task is the responsibility of the FAA in the United States and their counterparts in the other areas of the world.

We need to improve communications with both airlines and regulatory agencies. Clarity of the service bulletins, timeliness and emphasis of information provided regarding fleet problems should be improved. Guidelines should be developed for determining the adequacy of structural repairs in relation to long term operation and damage tolerance safety.

CONCLUSION

As the service life of airplanes is extended, high safety standards must be maintained to assure the airworthiness of aging airplanes until economics dictate their retirement. The various Boeing and industry programs I have described can provide the basis for this safe extended operation.

QUESTIONS OF SENATOR FORD
for Benjamin Cosgrove, Boeing

1. Question: Your testimony expresses concern over FAA's enforcement process, including the assessment of fines against carriers who do not meet FAA minimum safety standards. How would you assure compliance?

   Response: As I stated in my testimony (page 11 of my prepared statement), we feel that fines are certainly appropriate if an airline deliberately ignores safety. Obviously, an enforcement program must exist to levy such fines for the violators.

   Our concern is that the recent approach of imposing large fines can have a negative effect on airline maintenance programs. It stifles communications between the FAA and the carrier and it focus the need for the carrier to give more attention to record keeping than to the technical aspects of their maintenance program. For example, some carriers will not discuss compliance matters with their assigned FAA inspectors without their legal counsel present.

   FAA inspectors primary focus is looking at records. They need to spend their time (1) evaluating the carriers' maintenance programs for adequate technical content based on the carrier's operational environment, fleet size, experience, capabilities, and performance and (2) looking at airplanes and the inspections being performed on them. Training of FAA inspectors for these functions is required.

   Periodic spot checks or auditing of records should be sufficient to ensure that carriers comply with the established standards and maintenance programs.

2. Question: In 1986 a task force on Multiple Site Damage made a number of recommendations for manufacturers. Has Boeing implemented those recommendations?

   Response: Conclusions from the MSD committee reports were focused on recognition of probable cracking scenarios, testing

and teardown of airplanes retired from service, and on the influence of adjacent short cracks on fail-safety. Boeing has continued to conduct teardowns and fatigue tests of airplanes retired from service, including a model 737 completed in 1988, and a model 747 currently in progress. These activities are part of continued efforts since 1965 in support of aging airplanes and have led to updates of analysis methods and designs for both new and where appropriate aging airplanes. The likelihood of short adjacent cracks linking up rapidly has resulted in more demanding inspection requirements for some structure. These methods have been verified on the fatigue test of the 737 fuselage, lasting 130,000 cycles, equivalent to over 35 years of usage.

An additional recommendation included in the committee report was that cases where we have had in service pressure losses be examined for the presence of Multiple Site Damage. This has been done and the results have been provided to MSD task force members and incorporated in fleet maintenance recommendations.

3. Question: Your testimony mentions that major maintenance is increasingly being done by non-airline repair stations, and that maintenance discrepancies may be overlooked due to lack of familiarity with the plane. Do you suggest that only airlines do maintenance work? Could you give some examples?

Response: We do not suggest that only airlines do maintenance work. There is a definite need for non-airline repair stations to take care of maintenance in excess of operators' capabilities.

Examples where maintenance discrepancies have been overlooked include the following:

- Cases have been observed where structural repairs have not been in conformance with the Boeing Structural Repair Manual (SRM).

- It has been observed that blind fasteners have not been replaced with permanent fasteners at major maintenance checks as specified in the SRM. This may be a possible

reluctance on the part of the repair station to report all findings in order to remain within contract budget.

- There have been instances where cracks and corrosion have gone undetected because the repair station has focused on the specific tasks in the contract with the operator. Contracts should be written to permit repair stations to identify problems in areas of the airplane not specifically covered by the work package.

- Although FAA certified repair stations are required to perform work in accordance with the operator's manuals (FAR 145.2), instances have been observed where compliance has been inadequate due to lack of such documentation on site. Airlines should ensure that all necessary technical data is supplied to the repair station, including service bulletins and other technical information from the manufacturer.

4. Question: Could you elaborate on the Task Force decision to require replacement of certain parts rather than continued inspection?

Response: The new emphasis on requiring permanent modifications for aging airplanes in lieu of continuing inspections is based on the following considerations, some of which are unique to aging airplanes and the current airline marketplace environment. Major concerns include;

- Cumulative Damage Effects - To quote a recent editorial in Aviation Week & Space Technology/March 6, 1989, "experience is proving that hard-used transports, no matter how well built and maintained, are vulnerable to structural wear as they age." It has been shown that timely inspections and repairs during most of the life of an airplane provide an acceptable level of safety. However, as transport category airplanes begin to age the cumulative effects of fatigue, corrosion and accidental damage can result in an unacceptable level of risk. The new philosophy for aging airplanes, encompassed by the Task Force decision, is that known problems should be corrected by modification and inspections should be used

to detect unforeseen problems, as in the case with new airplanes.

- Human Factors - Experience has shown that human factors, such as qualifications, training, technique, and workload can result in significant variations in inspection reliability. Recent fleet problems, including the Aloha incident and the inadvertent discovery of a similar problem on another aging airplane after accomplishment of FAA mandated inspections, support the need for preventive modification instead of increased inspections to keep aging airplanes airworthy.

- Owner/Operator Changes - In today's marketplace where a transport airplane may have several owners or operators throughout its operational life, the public is exposed to the cumulative results of differing maintenance programs. The move towards mandated modifications will help re-establish a known airframe structural baseline as an airplane achieves maturity.

5. Question: You stated that Boeing is developing a corrosion prevention package for all models. What is the status of your efforts?

Response: Boeing, as part of an industry working group, and as directed by the Aging Aircraft Task Force Steering Committee, is currently participating in development of corrosion prevention and control programs for the Boeing model 707, 727, 737 and 747 airplanes.

This activity involves the development of model specific minimum baseline corrosion programs containing:

- o A basic task of inspection, rework/repair and application of corrosion preventive compounds.
- o Thresholds and repeat intervals for the basic task.
- o An implementation plan.
- o Reporting system.

This program is expected to be made mandatory by the FAA and will require a well coordinated effort by both FAA engineering and flight standards to assure consistency and full implementation.

The current schedule for completion of this activity for the Boeing models is the second quarter of 1989.

6. Question: You testified that some maintenance programs being used on older aircraft may not recognize the significance of age; that is they focus on flight hours or calendar time rather than cycles. In your opinion, has the FAA taken steps to address this deficiency?

Response: Flight hours and calendar times have been used effectively by a great majority of operators in defining maintenance check intervals. However, for operators that have a cycle to flight hour ratio that is significantly higher than the fleet average using cycles as the parameter to control maintenance check intervals is more appropriate. Also, since fatigue is a phenomenon based on cycles, inspections for fatigue damage on aging aircraft need to be repeated based on cycles accumulated. Recognizing the importance of cycles, the FAA:

- has approved the 757 and 767 MRB documents that require structural inspections to be based on cycle intervals.

- has directed that the Supplemental Structural Inspections which are based on cycles be added to the existing maintenance programs for certain aging aircraft.

- is in the process of evaluating a series of Service Bulletins with the intent to declare the modifications called out in them as mandatory. Incorporation of these modifications will eliminate some cycle-based repetitive inspections from the maintenance programs for aging airplanes.

7. Question: Do you believe the mechanics and maintenance personnel working for the airlines are adequately trained to detect and correct fatigue damage?

Response: Our observations at U.S. airlines are that most non-destructive testing (NDT) specialists seem to be adequately trained in their field. However, we are not sure if, in all cases, the mechanics who perform visual inspections are adequately trained. Current regulations do not require that a mechanic have special training to recognize structural defects. As such, there is no requirement, other than their own standards, that would force the airlines to provide training to mechanics and/or inspectors in inspecting aircraft structures. This is one area where new rulemaking requiring certification of inspectors may be advisable so that such training becomes a requirement. As for repairs, we believe that most U.S. airlines use adequately trained mechanics to correct fatigue damage.

Senator FORD. Thank you very much, Mr. Cosgrove.

There will be some questions in writing to each of you and we will not have all the questions for the record this morning, but hope that you all will respond in a timely manner.

So, I will start with Mr. Kizer and go from there.

Your testimony mentions, and I quote, "reliability-centered maintenance" as a program that focuses on demonstrated maintenance need, "demonstrated maintenance needs rather than arbitrary removal." Now, this sounds to me like you wait for something to break before you fix it. What do you mean by the term?

Mr. KIZER. Reliability-centered maintenance implies a philosophy which guarantees the longevity or the reliability of a part, not based on a time basis, but on a failure mode analysis that says the weakest part of the component should fail or does fail historically at a particular point in time. And it allows us to center our activities on those elements that have demonstrated the failure modes and to do the maintenance to address the failure mode and not just the entire component itself.

Mr. KIZER. We are doing the maintenance more effectively by addressing only the failure modes of the system and doing it in a more cost-effective manner.

Senator FORD. Do you have some history of how long the particular component will last, and then you replace it prior to that time?

Mr. Kizer. We schedule the maintenance activities to preclude failure. In other words, we want to bring the equipment in before the failure occurs in order to provide the reliability that we need to operate on a daily basis. So for each failure mode we schedule the component in for maintenance, or the aircraft in for maintenance. So that may mean that you may have several different intervals to correct the deficiency, or potential deficiency, in different areas of the component.

Senator FORD. Why should not then the FAA mandate a maintenance program for each carrier type and make it the same for each carrier?

Mr. KIZER. Mr. Broderick addressed that I believe earlier. When aircraft are introduced into service, they essentially have the same maintenance program for the all carriers.

Senator FORD. That is a minimum standard, I guess, that FAA puts out, is it not?

Mr. KIZER. That is right, and they are added to by the airlines themselves so that the actual maintenance program is more inclusive than the basic program for each carrier. But the problem is that as aircraft operate in a carrier's airline they are modified, so consequently, the aircraft vary between the carriers themselves and a standard program to accommodate the needs of all the various modifications to the aircraft as well as all the various operating conditions those aircraft daily operate in is really not a feasible situation.

We are looking at standardizing where we can in certain things, certain parts of the program such as the corrosion control program that both Mr. Cosgrove and Mr. Warren mentioned.

Senator FORD. Well, if you have a modification, though, is that not for safety reasons? Why should not all airlines that are flying that type of aircraft in their fleet be required to update it as relates to the safety of the aircraft?

Mr. KIZER. Well, all the modifications to the aircraft that are accommodated by the airlines are not always geared toward safety considerations. Some of them are reliability-centered. So consequently it would be an economic decision for other airlines.

Senator FORD. What is the difference between reliability and safety?

Mr. KIZER. Well, there is a great deal of difference. Reliability implies how frequently a component has to be removed, for instance. Safety implies of course some aspect of the failure mode that will cause an unsafe condition.

Senator FORD. To the general public, though if a part is reliable it is safe.

Mr. KIZER. I am not saying that you fly these components until failure, but if you have to remove a component every 100 hours, for instance, and you will do that before it fails, you may be able to improve the product by making a modification to it to allow it to operate 200 hours before failure, so that is an economic decision. How often you remove that product or that piece of the aircraft and what you do to it to improve its reliability.

Senator FORD. I think we could tear some holes in that, but I will leave that out there for a later point.

In your statement you say that aircraft retirement decisions by the airlines have almost always been driven by marketplace considerations. Where does safety come into play in these calculations?

Mr. KIZER. Safety is the primary consideration. It does no one any good to push a safety limit, and so safety is always the primary consideration for all facets of the airworthiness assurance group, be it the government, the manufacturer or the airline.

But historically, aircraft have been retired predominantly for technological reasons or for marketplace competitiveness rather than for any structural problems in the aircraft, with a couple of exceptions. Of course, there are notable exceptions where aircraft

had problems in their history and were retired because of those problems.

Senator FORD. Where does the safety line and the economical line cross?

Mr. KIZER. They never cross. Safety is always held above economic considerations, so there is never a conflict. In the development of the maintenance plan, safety is always the primary consideration and that is part of the decision logic that involves the maintenance program, so they never cross.

Senator FORD. Do aircraft carriers increase the inspection frequency as the aircraft grows older?

Mr. KIZER. Yes. In fact, taking the 727 as an example, an average increase is about 28 percent in the maintenance cost, which involves both the inspection and the replacement of materials over the period of time from 1978 to 1986, for instance.

Senator FORD. Have you done the type of inspection of Mr. Warren or Mr. Cosgrove? Are you familiar with taking the older aircraft and applying a procedure that would simulate additional age?

Mr. KIZER. Yes. We are familiar with the life extension programs, yes, and the fatigue testing that is done.

Senator FORD. I am beginning to get a little amazed that you increased one to 70 years and the other one beyond that and then you break them down. I wondered if you could have some of that maintenance for humans?

It is beginning to look awfully good to me.

Senator Ford. Let me ask you one last question, then. Much has been said about the recommendation of the industry task force to require replacement of certain parts rather than continued repair. When do you expect the first carrier will start the replacement parts? Is it true that the cycles are so high that most air carriers will have sold their planes before reaching that point?

Mr. KIZER. No. That is not true. Many of the carriers will have to start in the near term if they are going to complete all the mods on their fleet. But by the same token, many of the carriers—we estimated that something on the order of 50 percent—of the study group that was involved in this activity had already initiated these activities. These activities themselves came about as a result of the judgments of those operators that said, now is the time to do it, or you should have started. So we are starting now.

Senator FORD. Are you saying that the carriers started that and now we are requiring them to do it?

Mr. KIZER. Some carriers made those individual decisions, yes, and we are using that collective knowledge, that collective judgment base, to require it for all the carriers.

Senator FORD. Thank you very much. Mr. Warren, your testimony indicates that more stringent inspection and maintenance is required by owners and operators of older aircraft. Let me ask you this question, then. Do the existing FAA regulations cover that point?

Mr. WARREN. Yes, they do. The most specific and direct example is the SID program that has been installed by the FAA based on data prepared by the manufacturers for all of the current models in the Douglas fleet, for example. The DC-8, the DC-9, the DC-10

and the DC-3 programs are complete and are being installed. The 6s and 7s and the 4s are under preparation. All of those require special maintenance and inspections for older airplanes.

Senator FORD. I am beginning to learn the 6s, the 7s and 4s. Would you tell me what those are for the record? I know, but give those for the record please, sir.

Mr. WARREN. DC-6, DC-7, DC-4 are the early propeller-driven airplanes prior to the jet fleet, but after the DC-3.

Senator FORD. Are airline mechanics and maintenance personnel adequately trained to deal with the kinds of damage they are likely to encounter in older aircraft?

Mr. WARREN. I would have to do a bit of speculation on that. Let me say that I do have some first-hand knowledge——

Senator FORD. Speculate on the conservative side.

Mr. WARREN. I will do that. First, as mentioned before there is a program for the manufacturers to help get FAA inspectors more up to speed to the, particularly the SID documents and the special inspections required therein.

A lot of the concerns we have are that many people who are involved in the airline business are relatively new, like almost all industries, and there is a continuing education process required. This is something that needs to be addressed by everybody.

We are doing our share. We think that the airlines are doing their share. Whether anybody ever gets ahead and stays ahead on the education of all of the personnel is, I think, a question of concern.

Senator FORD. As a frequent traveler I get off of an old 15-passenger commuter and get on a DC-9. I feel like—knowing all and hearing all these things up here sometimes I become very concerned. I hope you encourage me that everything is all right out there on those two prospects.

Mr. Warren, in your testimony, you stated that two extraordinary actions have been taken by McDonnell Douglas and Boeing, and I do not want you to get in Mr. Cosgrove's territory, but you two might answer this question, since it will be your last one.

The first is extended service life testing and the second is in-service evaluation of the current fleet by manufacturer design teams. Let us talk about the life testing.

Douglas purchased one of the oldest DC-9s—I think you missed one, because I have been flying on it—out of service, and conducted extended service life testing to a total equivalent of nearly 70 years of service "(208,000 total of service and simulated flight cycles). After testing, a tear-down inspection of 14,000 fastener holes indicated that the useful service life had not yet been exceeded."

Now, tell me as a layman. You bought this DC-9 out of service, an old one, probably no one wanted to fly it, no one wanted to buy it, so you bought it. Now, what did you do from that point on until you tore it down?

Mr. WARREN. I would be very happy to describe that.

Senator FORD. I think it is important if we are going to get into aging aircraft. You hear so much about, well that B-51 is still flying. Boy, she is as good and as fast as she ever was. Well, it is completely rebuilt and that is what I tried to ask earlier. Can you rebuild an aircraft at less cost and have it go on for another 20

years? So I want you to tell me what you have done from that point on.

Mr. WARREN. First, we bought an aircraft out of service. We competed in the marketplace to buy it. We actually paid more for it than we got when we sold it new. The only reason we got it for the price——

Senator FORD. Well, what is new about that, Mr. Warren?

Mr. WARREN. The only reason the price was that low is, it was ready to be refurbished. In fact, we changed the tires before we took it to the test site. Once we got it to the test site we stripped all of the extra equipment out of it—all of the equipment, I should say.

Senator FORD. All of the equipment. Now, what is the equipment you are talking about?

Mr. WARREN. All of the systems associated with avionics, controls, hydraulics, so that the airframe itself, per se, was absolutely visible in the best possible light in every place.

Senator FORD. All right.

Mr. WARREN. We also stripped the paint off the airplane so that we did not have to be concerned about false indications with paint cracking. We then did a very thorough inspection of the airplane. We found approximately 50 discrepancies, of which 80 percent were associated with damage from altercations on the ramp.

About 10 of those discrepancies were fatigue or corrosion-related damage. Two of those we repaired just as they would have been repaired in service. Two of those—three of those, we let go just exactly the way they were for the life of the test.

We pressure cycled the fuselage so that the total number of cycles got to 208,000. Originally, the airplane had 66,500 when we bought it, so we added another 160,000-plus cycles to that exposure.

Then we removed large specimens from both the wing and the empennage and put those in a laboratory testing system so that we could do spectrum loading, and we simulated the continued use of the airplane for the remaining equivalent time by doing testing of the wing and empennage panels in the laboratory.

All the time we did this, we did inspections much like the inspections that would be done in service. We used corresponding procedures that were somewhat easier because we had removed all the interior and the systems from the airplane.

If we found any damage that was minor, we repaired that, just as it would be repaired in service. If we found any significant damage we duly recorded that. We processed it and we have issued some service bulletins. There are some field changes associated with that. So we extracted all of the on-going knowledge. We did learn one new thing from that that we have not seen prior, in our experience.

After we finished all of that work, we then pulled the airplane apart, partially. We selected critical fasteners and removed those fasteners and did nondestructive inspection testing of those holes.

Now, the reason for doing that is that, as a generality, cracking starts from holes. Small cracks are hard to discover because they are hidden by the fastener heads so by removing the rivets we have access to the holes themselves and can do what I would call the ultimate inspection in terms of precision and detectability. And in

that process we found that we still did not have any significant cracking in these 14,000 holes, which were located at the locations which are key, most likely to lead to failures.

So our conclusion from that is that the airplane airframe still had a significant useful life. For example, if you owned it and if you wanted to operate it some more you could very practically modify certain parts of it and continue to operate that airplane, even beyond these 208,000 cycles.

Senator FORD. Now, these were all simulated cycles.

Mr. WARREN. Yes. The original airplane when we bought it had 66,500 cycles. We added to that enough to have a total of 208,000.

Senator FORD. How did you add those cycles? That was still on the ground. You did not take it up in the air and land it 160 times, did you—160,000 times?

Mr. WARREN. We did not fly it. That simulation process included first, pressurization cycles for the fuselage. That does most of the fuselage fatigue damage—just pressurization only.

For the wing and the empendage, where the accumulation of damage is associated with normal flight, we did spectrum loading in the laboratory using stress levels, flight-by-flight representation for 160,000 cycles.

Senator FORD. It seems impressive to me, Mr. Warren but when you say normal flight, how many hard landings did you have?

Mr. WARREN. I misled you with the word normal. We put in spectrum loading representing what we think happens in real service. That means a reasonable number of regular landings, a reasonable number of firm landings, a few hard landings. We had normal flight with and without gusts. We had flight with maneuvers. We had flights with the control surfaces moved, including flaps. Every aspect of flight that is required to properly simulate the fatigue exposure of the parts we tested was included in the test.

Senator FORD. Thank you, Mr. Warren. Mr. Cosgrove, you want to follow-up on that, what you were able to do? I think you had a longer lifetime cycle, as I remember your testimony.

Mr. COSGROVE. Well, the two airplanes that we have been dealing with recently are the 737 and like Dale Warren, we got an airplane at about 60,000 flights which was a Piedmont airplane run down to Charlottesville and we applied another 70,000 flights to it which equivalently is getting close to, maybe 34 years of experience. And we fundamentally took the aircraft and pressurized the fuselage, and we did watch the aircraft and watched fatigue crack and grow and see whether or not it was damage tolerant, fail-safe and used it for data in which we would predict as to what we might do on inspections and maintenance in the aircraft, when it is on the line in the airline service.

Then the 47 we purchased from Japan Airlines, and it had about 25,000 flight cycles and I think it was about 18 years in service and what we did with that, we are in the process now of adding another 20,000 cycles, but before we—we took the aircraft and we had mods that we had sent out in service bulletins because we had some cracking in section 41 and you remember that in about 1985 we had some problems with that.

So we took the aircraft and applied to the fuselage all the modifications that we had recommended by service bulletin and put it in

this aircraft. And now we are, as you say, updated the aircraft, and we are going to put another 20 years of pressurizations on the aircraft. And that will be completed next year. Early next year, some time.

Senator FORD. This is all still the same procedure Mr. Warren followed?

Mr. COSGROVE. Yes.

Senator FORD. How do you simulate a solid landing and a hard landing?

Mr. COSGROVE. Well, there is such a thing as an SN curve. It is a stress cycle curve, and you can represent a hard landing by—a real hard landing is about five feet per second. The airplanes are designed for about nine or 10 feet per second and you may get, maybe about a G and a half on your fanny as you land. But you just simulate it by pulling down on the wings and pulling down on the body around the landing gear.

I think he was representing that as far as, he took specimens of the wing and put them in a machine and fundamentally put the stresses in them that he would predict would happen with that landing. Because the analytical work is pretty good and besides that during flight testing of the airplane as a new model you strain-gauge the heck out of it, and so you know what the stress levels are.

Senator FORD. Have you done any testing about rebuilding an aircraft versus purchasing a new one?

Mr. COSGROVE. I am sorry, Senator. Say that again, please.

Senator FORD. Have you all done any study as it relates to reconstruction of an aircraft, an aging aircraft—ripping it down and replacing it, putting it back in service again—versus a new aircraft?

Mr. COSGROVE. No. We do recommend that the airlines change certain parts at certain times during its useful life. But we have come to the conclusion that just taking an airplane apart and putting it back together again, like you might say, taking the cylinders out of an engine and reboring them and that sort of stuff why, you do it when you have to do it and only in the places that you have to do it.

We think that the testing that we do and the analytical predictions will tell us where we have to do this, so we do not say that you have to take a whole airplane apart. We do think that you ought to look in certain areas and maybe replace certain parts, rather than inspect them.

Senator FORD. Well, you talk about reboring an engine. Let me give you a back yard mechanic's view of that. You jerk your engine out of the car and you give that to the parts store downtown and they give you a new, what they refer to as a new, rebuilt engine.

You put that in the car and so for all practical purposes you have an engine that is basically new. It has been reworked. It even looks new and when you start it up and it gets warm it smells new. Do you do anything like that to an aircraft? Can you take it, like you are breaking it down now and leave the skeleton and rebuild it for something less? I think Mr. Warren's head is bobbing up and down there a little bit. Mr. Warren?

Mr. WARREN. Yes, Mr. Chairman. I would like to comment on that. I think you are recognizing the fact that our manufacturing

industry is hard-pressed to keep up with the airline demands for increased lift and that is not enough to also cover the fact that we have aging airplanes that we would like to retire. There is a feasibility study going on at Douglas to evaluate the economics associated with the idea you suggest and that is to have a restoration center for older airplanes.

Senator FORD. Well, maybe that is a better word. Restoration rather than rebuilding, you know. Mr. Cosgrove, let me ask you this: some aviation groups suggest that an aircraft should be subjected to a complete tear-down and recertification when it reaches a particular age or has sustained a certain number of cycles. Do you have an opinion on these suggestions?

Mr. COSGROVE. Well, you know I think the manufacturers and the regulatory agencies are constantly looking at airplanes. I think that they are getting data from the fleet and they have data from tear-downs of older airplanes and airplanes that have ended up, like Dale has said and I have said, they have gone 40 years rather than 20. And I think that the data is there to keep flying these airplanes and doing what we are doing today.

I think that what we do today is good. I think it is safe, and there is no question in my mind that the aging airplane groups that we have put together, we have got together and discussed a lot of things and I think that what we are doing is the proper way to go.

Which is—there are certain areas that we know we should quit inspecting and do some replacing, but I do think that we have to continue to inspect aircraft and it becomes an issue like this: if you took an airplane and made it brand new again and tore it down and made it brand new again, you are still going to have to inspect it.

Because there are other things that happen to an aircraft such as corrosion—people carrying fish in the belly of aircraft. God forgive it, sometimes the airlines run fork lift trucks into the side of airplanes and put holes in them. So it really is that you have got an airplane that you know what it will do and if you continue to inspect it and maintain it I do not think you have to tear it down and put it back together again. But you do have to watch it.

Senator FORD. Do you believe that the FAA should require all airlines to use the same maintenance program for each model of aircraft?

Mr. COSGROVE. No. I think there should be a minimum. My view of it is that I think there are some airlines that fly, if you take them and fly into Micronesia where you get a lot of salt and coral runways that they should have a more extensive corrosion prevention program and inspection program than the minimum standard.

Senator FORD. Should FAA have a different standard?

Mr. COSGROVE. I think they do. I think they absolutely do have a different standard for those airlines that go into areas where they have more corrosion, contamination and that they have to have a preventive program that is more often than with a normal aircraft that is flying in the northern climates.

Senator FORD. Well, what you and others have said today is that with proper maintenance aircraft can fly indefinitely and that the retirement of aircraft is economic and not a safety decision. Are we

to assume that all of the recent incidences, accidents involving older aircraft, are due to inadequate maintenance?

Mr. COSGROVE. Well, we have got to put the aging airplane problem a little bit in perspective. You know, if you look over the past 30 years, you will generally find that 85 percent or better of the incidents, accidents involving aircraft are due to causes other than what I would call the machinery itself. It is mostly due to human error, like colliding in the air or missing runways and so forth. And that from a structural standpoint, our view at Boeing is that of the incidents we talk about, maybe 4 percent of all the things that happen are a result of the structure.

So, I—not to downgrade the fact that we have got aging airplanes, we have got to take care of them because it is the guts of flying to keep that structure right and so forth, but we do not want to get to the point where you spend all your money on working and doing research on aging airplanes when we do have another problem out there, when the majority of accidents are occurring for some other reason.

Senator FORD. Well, let me make reference to a car. Everybody understands as a car gets older, it needs more maintenance, and you have to look after it a little more.

Mr. COSGROVE. We have no argument, Senator, that when it comes to the aircraft getting over 15 years, the frequency of inspections—you should have more inspections as the airplane ages. You should look at it closer, and you have to beware of corrosion. There is no question in my mind about that. As they get older, you have got to take better care of them.

Senator FORD. I think you are now coming around to what the problem is, and the attitude as it relates to the aging aircraft.

You stated that the Boeing survey teams found considerable—and I quote—"considerable variations" in aircraft condition and airline maintenance procedures. Did this appear to have any relationship with the profitability of the operator?

Mr. COSGROVE. I am hard-pressed to answer that because I am not an expert in that field. I would prefer not to answer that question because I am really not sure, Senator.

Senator FORD. Do any of the other witnesses take the same position, that you all would fail to make any kind of statement that an airline would just not dare fail to replace parts or improve its maintenance because it would cost a little more money, put them on the edge of not making any money?

Mr. COSGROVE. Senator, let me say one thing that I think we have noticed, and that is that maybe part of the problem that we saw when maintenance was not to what we would call the standard that we thought it ought to be in an airline. One of the things that we noticed was maybe it was because they did not know any better. They did not have the experience with the aircraft, and this might have been part of the issue as to why the maintenance was not up to a standard. But as soon as——

Senator FORD. Whose fault is that?

Mr. COSGROVE. Well, I am not so sure I know.

Senator FORD. If it is the FAA's fault, say so. If it is the airlines' fault, say so.

Mr. COSGROVE. Well, I would have thought that it might be the experience in the airline and why they did not have the experience—I am not sure why they did not have the experience.

Senator FORD. Mr. Kizer, you want to get in on this? I think we are beginning to move a little bit here.

Mr. KIZER. Yes, I would like to make a couple of statements, Senator.

First of all, I cannot speak to the individual airlines, because we do not have any individual airline data. But we do have collective data for the industry, and I think as Senator McCain indicated, the significant increase in maintenance dollars that have been spent since 1978—we went from $2.6 to $6.1 billion.

Senator FORD. You could say that is the cost of maintenance from the individual, not necessarily the group. There have been a lot of factors as it relates to cost, not necessarily in parts.

Mr. KIZER. That is true. But what I am saying is that we expected the cost of aircraft maintenance to go up as they got older, and I think we are realizing that cost.

I presented some data with respect to the 727. One airline that we deal with estimated that overhaul costs for the older aircraft were going to go up from 10 to 25 percent for this overhaul cycle, as opposed to the previous overhaul cycle for the aircraft. So yes, it does cost more to maintain older aircraft and, yes, the industry is putting more money into those aircraft to maintain them properly.

Then the other aspect is the effect of that maintenance, and I think the OTA study showed that both the reliability and the safety of the industry have improved since deregulation and particularly over the last five years. So, we are putting the money in, and we are seeing the effects of it in improved reliability and the safety of the operating system.

Senator FORD. Well, since you jumped into this, do you think that the profitability of an operator is a factor in maintenance?

Mr. KIZER. Maintenance was never deregulated, and I cannot speak for individual airlines. But I know that the airlines I have been associated with, we never estimated what the profit was going to be for that quarter when we determined what the maintenance requirements for the aircraft were going to be for that quarter or for that year. And that is the way it has to be or you cannot stay in business.

Senator FORD. Well, if the first quarter looks bad, what do you do the second quarter?

Mr. KIZER. If the first quarter looks bad and the aircraft need maintenance, you do specify what level of maintenance and what projects are needed and why they are needed. You may cut down on marketing projects. You may not change the seats or change the decor of the aircraft, but you do the maintenance that is necessary to be done on the aircraft.

Senator FORD. Why would Mr. Cosgrove, a man of his reputation, say that it is the freshman entrants into the industry that are creating a lot of our problems? Why should not that standard be as high as those who have been in it for a while?

Mr. KIZER. There is a question as to whether we should apply standards of training and qualification for, for instance, inspectors and mechanics.

Senator FORD. Why should there be any question? Why should not the maintenance on the DC-9 for an airline that has been in business for a long time and the maintenance and inspection on a DC-9 just entering the industry with a new company be the same?

Mr. KIZER. Well, there is no question about that. The maintenance plans and the maintenance requirements for those aircraft are predicated on the age of the aircraft, the type of the aircraft, and there is the minimum standard for all the airlines that operate the aircraft.

The question was that we are now allowing the airlines to specify their own training programs and their own standards and qualifications for their mechanics and their inspectors. We are addressing that issue in the Airworthiness Assurance Task Force to determine whether some standard should be established for the industry as a whole, and we will certainly drive in that direction with respect to inspectors.

Senator FORD. I just cannot get it in my thick head, I guess, why there should be any question that you ought to go ahead with the strict training and education across the board. There is something about that that bothers me. You are trying to decide whether you ought to do that or not.

Mr. KIZER. Well, the question does not exist as to whether some standards should exist. The question is should it exist universally or should each airline define their own in relation to their needs and in relation to the FAA requirements. And what we are doing now is saying as an industry that first of all we are looking into it. But, secondly, we are likely to establish standards for training and qualification of inspectors, particularly as it applies to non-destructive testing.

Senator FORD. Are we running into the problem of a minimum FAA requirement with the airlines being given the opportunity to do basically anything on top of that they want to do? Should we raise the minimum requirements? Should we have a requirement for all aircraft—I will get back to that question.

Mr. KIZER. No, I do not believe so, and I think we have talked about that.

Senator FORD. I understand we have talked about it several times, but then you get right up to the brink and we do not get beyond the brink. We always begin to take a couple steps back.

Mr. KIZER. No. We are addressing the effects. We are addressing the problems that we see, I think, in a very effective manner.

Senator FORD. That is your opinion. That is in the eye of the beholder, now. You know, you are doing very well, and you are representing your association very well here this morning. But there is a point that I am trying to get to that you say you should leave it up to the airlines and now you are having a study to see if we ought to improve. You say the minimum standards are what FAA requires. Maybe we ought to raise the minimum. And you say that we ought not to have a minimum on each aircraft, whether it is a 727, 737 or 747 or DC-9.

It seems to me there ought to be a minimum standard which is of the highest quality, and that is the minimum for whatever aircraft that might be out there.

Mr. KIZER. The minimum standards do exist, and we are evaluating whether they should be changed or whether they should become universally standard for all the airlines. But they do exist. They exist in the regulations.

Senator FORD. That is the minimum standards you are saying. Are they high-quality standards?

Mr. KIZER. Certainly. The safety record of the industry speaks to that issue.

Senator FORD. Mr. Cosgrove, let me ask you one last question, and I do not know whether Senator McCain is going to be able to return or not, and I do not have any questions that he would like to ask. He does have a great deal of knowledge of aircraft, and he has a lot of tenacity. He and I get along very well.

The subcommittee is aware that Boeing, like McDonnell Douglas, has a backlog of several years for orders for new aircraft. I guess that is the best way to be in business. But in your view, has this backlog put added pressure on the airlines to operate aging aircraft and, accordingly, should we be concerned that this backlog therefore might be a crutch for some to lean on as the reason for having problems with aging aircraft?

Mr. COSGROVE. Well, there really is not any question with the growth in traffic that I think that our inability to deliver more aircraft is a factor in whether or not the airlines will hang on to some of these airplanes a little longer. There—as long as fuel is down where it is, why, they are efficient, they make money for the airlines, and they will keep them until they can get new aircraft.

So, I do believe that we will probably have some aircraft in the fleet of airlines longer as a result of the inability of MacDac and—Douglas, rather, and Boeing and Aerospeciale to deliver airplanes. I do not know that it is a crutch.

I think that the airplanes are good. I do think that—I know it is an old saw—properly maintained and inspected aircraft will last indefinitely and, yes, we are trying to ensure that through the aging aircraft committees that we have, got started by the ATA, that we are addressing those standards, as you put them, to make sure they are high safety standards, not minimums.

And I think we are convinced that the spectre of another Aloha—we do not—nobody wants this. We did not want the first one, and we do not want any more, and I think we are attacking the problem in a conservative, aggressive way and that I believe that the safety of the aircraft that we have got out there, even though they maybe 18 years or 20 years or 14 years, they are pretty safe right now. I think that we are doing more than we have ever done before.

Senator FORD. You and Mr. Warren may have touched on this, but is either company doing any research as it relates to human factors in non-destructive testing?

Mr. COSGROVE. Yes, we are looking at it constantly. We recognize the problem of being in 40 degrees below and somebody out there looking at rivets; it is not a very enjoyable job. And so we are trying to see if we can make it more palatable so that it is a situation that he does not get bored or he does not freeze his fingers off or his tootsies off as he is doing this. We want to do it faster, but we still want to do it in a manner that is responsible.

And we are looking at it, but we have not found anything that is an outright invention like a light bulb or anything that you can shoot a shot at an airplane and say this is where the troubles are or take a CAT scan of it or anything like that.

We are still of the opinion that you need experienced inspectors and engineers in and around airplanes at all times, and that will keep those aircraft safe.

Senator FORD. Mr. Warren, do you want to add anything to that.

Mr. WARREN. Yes. I would comment on two things. One is that we found a very practical and worthwhile strategy in getting our SID program in place. We have incorporated a significant use of modern NDI techniques, non-destructive inspection techniques.

And to verify that those were valid before we put them in our books and before we encouraged the FAA to make them a requirement is we took them to airlines all over the world and worked with the airlines and had airlines actually do inspections with our coaching so that we were (a) training, and (b) verifying that the procedure would work. This is a very valuable and practical thing.

There is another aspect to this. There is a continual effort to advance the state of the art of non-destructive inspection. This is extremely worthwhile and practical. The latest idea that we have under evaluation—and we have an effort going—it is really a business liaison is probably the best way to describe it. There is an organization that claims to have a procedure to do something like seismic evaluation.

The way it would work is to put sensors across appropriate places on an airplane and then to pressurize it, for example, or some other load condition and if there is any damage in the airplane or if there is any damage growing in the airplane, there is an acoustic emission, and it can be generally located using the same procedures that the seismologists use to locate the epicenter of an earthquake and thereby speed up the process and add reliability to the process of NDI Inspection.

This is just the latest of many ideas. We had a working program with a specialist from the oil fields some three years, four years ago. They use a technique that uses infrared photography to detect air flow through cracks in pipes, and there is a special characteristic of that that leads to a temperature change in the mechanism detectible by a highly sensitive infrared photography.

We experimented with that. It did not seem to be too practical. But there is hope and there is a continuing quest to improve our bag of tools for doing NDI.

We also are—as we go through both of these programs, working with our operators and also researching techniques, we continually try to incorporate human factor aspects into that.

Senator FORD. Mr. Kizer, do you have any final statements you would like to make?

Mr. KIZER. You asked about the human factors. That is one of the big efforts that we are addressing with respect to research and development.

We want to look at the human factors aspects, not only from the design standpoint as, first of all, are the areas accessible by human beings, and can they do the mission, the job they are supposed to be doing in the area. But, also, the common principles that we need

to apply to our industry, in terms of the environment, the tooling, the instruction, and we see that, the communications process is one of the big issues that needs to be explored and improved—communications between the manufacturer, the FAA, and the airlines and out to the man who has to turn the wrench on the aircraft.

And so we are looking into that, and we will make recommendations toward it.

Senator FORD. All three of you have been very fine witnesses today. I appreciate your patience and just advise you this is the tip of the iceberg. This is the first hearing. We are going to continue some more. So, this hearing is not adjourned. It is recessed.

[Whereupon, at 10:55 a.m., the subcommittee adjourned, subject to the call of the Chair.]

98-741 (104)